Essays in International Macroeconomics

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Submitted in partial fulfillment of the

requirements for the degree

of Doctor of Philosophy

in the Graduate School of Arts and Sciences

COLUMBIA UNIVERSITY

2016

ABSTRACT

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This dissertation combines theoretical modeling and empirical analysis in macroeconomics, with a focus on open economies. It contains three chapters that study macroeconomic dynamics in the presence of credit frictions and the scope for stabilization policies in this context.

Chapter 1, “Macroeconomic Effects of Commodity Booms and Busts: The Role of Financial Frictions”, studies the real effects of commodity price shocks in small open commodity exporters; and the role of financial frictions in the transmission of these shocks to economic activity. I begin by estimating a panel VAR system for two groups of countries heavily exposed to commodity goods exports, one containing only advanced small open economies, and the other only emerging small open economies. I show that commodity price shocks are important sources of business cycle fluctuations, and have stronger effects on real activity, credit, and country interest rate in emerging countries. Motivated by these results, I construct a multi-sector open economy model with a banking sector to gauge the importance of different financial frictions in the transmission of commodity price shocks. I find that the main transmission channel is the interaction between the differences in working capital constraints at the firm level and the effect of commodity prices on the country interest rate. Moreover, I show that the financial accelerator and balance sheet mismatches in the banking sector don’t have a relevant quantitative amplification effect.

Chapter 2, “International Reserves, Credit Constraints, and Systemic Sudden Stops", analyzes the puzzling fact that emerging markets hold very high levels of international reserves and foreign liabilities simultaneously. Moreover, these holdings are positively correlated, which leads to an income loss that might reach 2% of GDP per year. To address this issue, I propose a new motive for international reserves accumulation, namely its role

as implicit collateral for external borrowing. In this context, I evaluate whether the role of international reserves as collateral can explain the high levels of international reserves that we see in practice and find that the optimal level is close to the average reserves-to-GDP ratio in Latin American countries. Additionally, the optimal behavior during crises implies an increase of reserve holdings before a Sudden Stop and a small reduction during it, which is coherent with what was observed in the recent Global Financial Crisis. Finally, an alternative policy of keeping reserves at a constant level equal to its average value all the time yields very similar result to the optimal policy during sudden stops, highlighting the stabilizing role of reserves even if Central Banks don't use them at all.

Chapter 3, "The Real Consequences of Countercyclical Capital Controls", coauthored with Savitar Sundaresan, analyzes the effects of capital controls on real activity in Brazil, the most preeminent case of controls being imposed countercyclically. We find that capital controls have a significant negative impact on investment. The macro analysis uses a synthetic control method and finds that investment could have been approximately 20% higher if controls had not been put in place. The micro analysis uses a panel data approach and finds that the controls reduced the investment to assets ratio by as much as 40%, with some of its effects mitigated by the extension of subsidized credit by the government through the development bank. These results indicate that the renewed support for controls since the Great Financial Crisis should be more cautiously evaluated as it might harm the potential growth rate of Emerging Economies for a long-lasting period.

Contents

List of Figures

List of Tables

Acknowledgements

I am grateful to Martín Uribe for constant support throughout this process; his guidance and encouragement during the development of this work made the experience much more valuable and enjoyable. I especially thank Stephanie Schmitt-Grohé, who always gave me excellent feedback, assistance, and advice. I would also like to express gratitude to the other members of my dissertation committee, José Alexandre Scheinkman, Patrick Bolton, and Richard Clarida, for their guidance and great comments.

My work also benefited from very useful comments and suggestions from Saki Bigio, Frederic Mishkin, Tommaso Monacelli, Emi Nakamura, Jaromir Nosal, Ricardo Reis, John Shea, Jón Steinsson, and Michael Woodford.

This dissertation was partly written at the Federal Reserve Bank of St. Louis while I was a dissertation intern. I am especially grateful for their hospitality and for all the feedback I received when I was there.

I would also like to thank my classmates, Tuo Chen, Mariana García-Schmidt, Yang Jiao, Shaowen Luo, Seunghoon Na, Pablo Ottonello, Ilton Soares, Savitar Sundaresan, and all the participants of the Economic Fluctuations Colloquium, Monetary Economics Colloquium, and Financial Frictions Colloquium at Columbia University for all their help and challenging discussions.

Finally, I am grateful to my family and friends, who were crucial during all these years.

In particular to my mother for her support and encouragement throughout my life; and to Núria Saldanha, who joined me in this ride, for her invaluable company, love, and support.

To my late father

Chapter 1

Macroeconomic Effects of Commodity Booms and Busts: The Role of Financial Frictions

1.1 INTRODUCTION

Terms of trade movements are usually associated with macroeconomic fluctuations in small open economies but the effects are heterogenous among countries. For example, in the last commodity price boom, output growth in advanced commodity exporters was somewhat stable compared to the previous decade, while emerging commodity exporters growth rate more than doubled on average (see Figure 1.1).[1] Given the relevance that commodities have on these economies, understanding the channels by which the effect of commodity prices affect economic activity is crucial from a policy perspective.

This paper evaluates quantitatively the importance of commodity price shocks for business cycles and the different channels through which these shocks affect small open commodity producing economies, focusing on the importance of financial frictions in the transmission of these shocks. My analysis proceeds in two steps. First, I estimate a panel VAR system for two groups of countries heavily exposed to commodity goods exports, one containing only advanced and the other only emerging small open economies.[2] I show that commodity price shocks are important sources of business cycles and have stronger effects on real activity, credit, and country interest rates in emerging countries. Additionally, including commodity price shocks in a panel structural VAR makes the contribution of interest rate shocks for real activity fluctuations in emerging economies to be almost negligible, a result in contrast with what was found in Neumeyer and Perri (2005) and Uribe and Yue (2006).[3] This last result indicates that interest rate shocks capture the effects of commodity price shocks when they are omitted from the analysis, leading to an overestimation of their importance for business cycle fluctuations.

1. Commodities represent around 50% of exports and 10% of GDP in both countries as we can see in Table 1.1.

2. I prefer to use the panel data methodology because it increases the efficiency and power of the analysis as individual countries' VARs would have too many parameters compared to the time series length.

3. Neumeyer and Perri (2005) and Uribe and Yue (2006) find that interest rate shocks explain around 30% of movements in emerging economies aggregate activity at a business cycle frequency.

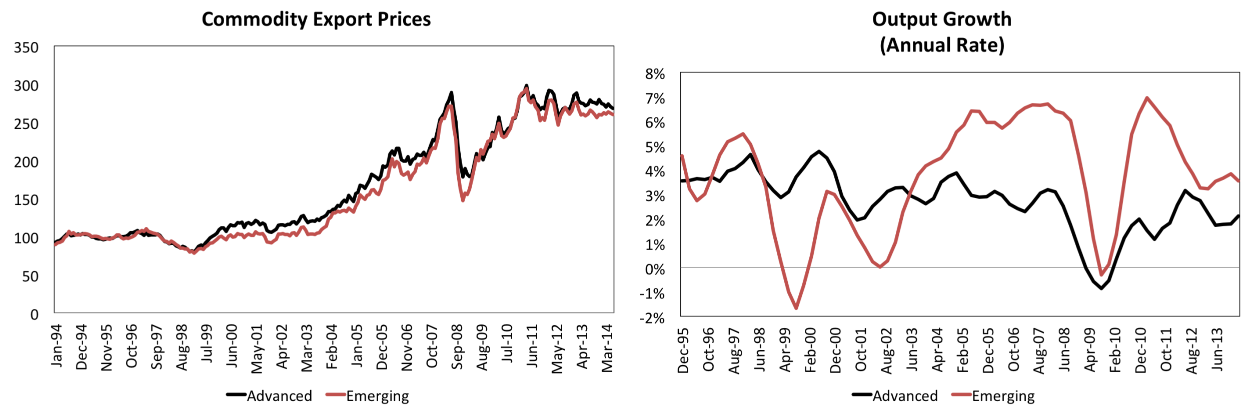

Figure 1.1: Commodity Export Prices and Output Growth in Commodity Exporters

Source: IMF Primary Commodity Price System, UN COMTRADE and National Sources.

In the second part of my analysis, I build a multi-sector open economy model with a banking sector to study the mechanism by which financial frictions can amplify the effects of commodity price shocks. The key idea in the model is that a commodity price shock triggers price movements that interact with financial constraints both at firms and banks, transmitting this shock to the rest of the economy through a change in financial conditions for all sectors. After a favorable commodity price shock, there is a currency appreciation, a rise in the price of nontradables and, especially for emerging economies, a decline in the interest rate charged by foreign lenders due to lower country risk.[4] In an environment where banks are subject to leverage constraints and finance their operation through foreign borrowing in tradable units but lend locally in nontradable units, a mismatch arises in banks' balance sheets. Consequently, the increase in the price of nontradables reduces banks' leverage and relaxes their borrowing constraint while the decrease in the country interest rate reduces their funding costs. Accordingly, bankers are able to get more funds from foreign investors and expand the supply of credit for the whole economy, leading in equilibrium to a lower lending rate. Finally, the lower interest rate reduces the costs related to working capital for firms and leads to a further boom in the commodity and non-tradable sectors while the effects in the industrial

4. For evidence on the negative comovement between commodity prices and country risk in emerging economies, see Bastourre et al. (2013) and Fernández, González, and Rodriguez (2015)

sector are ambiguous, as they have now also more costly inputs. The close relationship between commodity prices and foreign borrowing by the banking sector in small open commodity exporters can be seen in Figure 1.2.

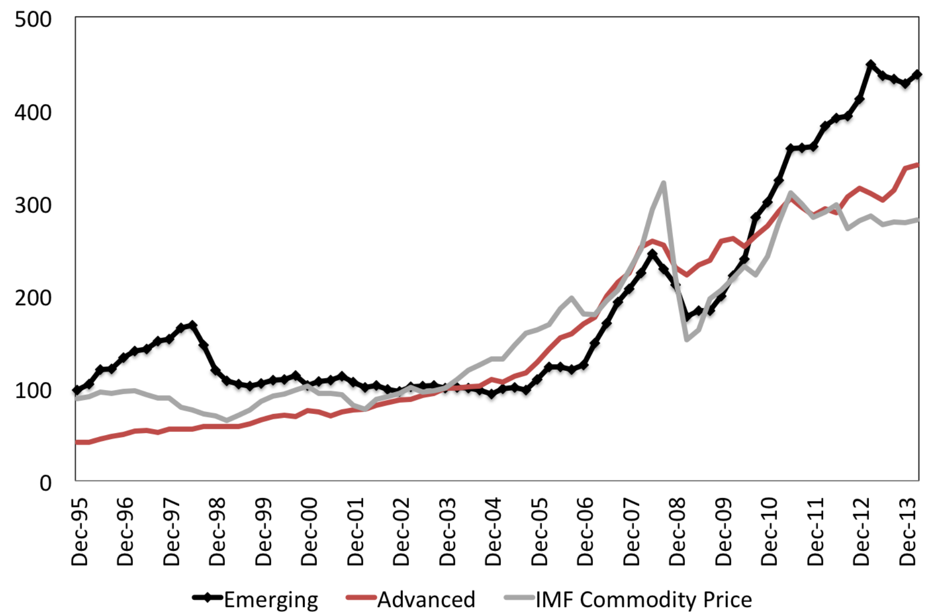

Figure 1.2: Banking Sector Foreign Financing

Note: The data are the simple average of the sum of external loans and international debt securities vis-a-vis the banking sector from 1995-2013 normalized for Dec 2003 = 100 for the Emerging (Argentina, Brazil, Chile, Colombia, Peru and South Africa) and Advanced (Australia, Canada, New Zealand and Norway) main commodity exporters.

Source: BIS locational banking statistics Table 7A.

I estimate the small open economy model with financial frictions using Bayesian methods for both groups of economies, advanced and emerging, and I show that the model is able to account for the different effects of commodity price shocks on these two groups. This framework also allows me to evaluate the quantitative importance of four previously studied channels through which financial frictions can amplify the effects of commodity price shocks

1. ***Working capital channel*****:** the change in working capital costs when the interest rate moves due to a commodity price shock;
2. ***Financial accelerator channel*****:** the change in credit supply when banks are subject

to leverage constraints for foreign borrowing induced by fluctuations in banks' net worth due to commodity prices movements;

3. ***Balance sheet mismatch channel*:** the change in banks' net worth resulting from movements in the price of nontradables induced by commodity price shocks in the presence of mismatches in banks' balance sheets;
4. ***Country interest rate channel*:** the change in the country interest rate when commodity prices move due to a change in the country sovereign risk, especially for emerging economies.

I conduct a counterfactual analysis and find that the main transmission channel is the interaction between the working capital and country interest rate channel. Moreover, I also show that the financial accelerator and balance sheet mismatches in the banking sector don't have a relevant quantitative amplification effect.

The small role of borrowing constraints in the transmission of shocks found in this paper might seem surprising as they have received a lot of attention in the theoretical literature recently. However, there is little agreement about their quantitative relevance. On the one hand, Brunnermeier and Sannikov (2014) emphasize the role of nonlinearities and asymmetries to generate quantitatively relevant amplification arising from the financial accelerator mechanism. On the other hand, Kocherlakota (2000) argues that, although they might generate an arbitrarily high degree of amplification, this theoretical possibility is not robust because, depending on the parameters of the economy, prices might not respond too much to income shocks. In the same vein, Cordoba and Ripoll (2004) find that amplification is close to zero for standard values of capital shares and intertemporal elasticity of substitution. Liu, Wang, and Zha (2013) confirm their findings by showing that only shocks that impact considerably prices directly related to the financial frictions can trigger strong amplification effects. In fact, I show that the key reason for the small amplification effect in my setting is the small and short-lived effect on the spread charged by financial intermediaries to firms.

Layout. The rest of the paper is organized as follows. Section 1.2 discusses the relationship with the literature. Section 1.3 describes the data, discusses the main stylized facts, describes the panel VAR specification and discusses its results. Section 1.4 describes the theoretical framework and the different equilibrium concepts. Section 1.5 details the estimation of the model and presents its main results. Section 1.6 concludes.

1.2 Relationship with the Literature

This section discusses the contribution of this work to three strands of the literature.

Effects of External Shocks in Emerging Economies. This paper contributes to the literature that studies the effects of external shocks in small open economies. Neumeyer and Perri (2005) and Uribe and Yue (2006) analyze the effect of interest rate shocks and find that both US interest rate shocks and country spread shocks are crucial drivers of business cycle in emerging economies. Mendoza (1995) and Kose (2002) study the effect of terms of trade shocks by estimating a process for them and feeding it to a small open economy business cycle model to compute the variance of macroeconomic variables induced by these shocks. After that, they compare it with the actual variance of the corresponding variable and find that at least 30% of macroeconomic fluctuations should be attributed to terms of trade shocks. Lubik and Teo (2005) estimate a DSGE model for five developed and developing economies and find that world interest rate shocks are the main driving forces of business cycles in small open economies while terms of trade shocks are not relevant. However, they acknowledge that their results might be related to the importance of allowing for a richer production structure to accurately capture the contribution of terms of trade shocks to business cycle fluctuations, an issue addressed in this paper. Justiniano and Preston (2010) estimate a structural, small open-economy model of the Canadian economy and show that it cannot account for the substantial influence of foreign-sourced disturbances identified in numerous reduced form studies.

They also show that these results are due to the model's inability to account for comovement without generating counter factual implications for the real exchange rate, the terms of trade and Canadian inflation, which is not true in the setup proposed in this work. Akinci (2013) uses a panel VAR methodology to show that shocks to global financial risk are an important source of business cycle fluctuations in emerging economies. Moreover, the inclusion of global financial risk makes the contribution of the global risk-free interest rate negligible, although country spread shocks are still an important source of fluctuations in emerging economies. Schmitt-Grohé and Uribe (2015b) estimate both structural VARs and theoretical models for individual countries to evaluate terms of trade shocks and find that in the empirical SVAR these shocks explain around 10 percent of movements in aggregate activity. Moreover, they find that at the country level there is a disconnect between the empirical and theoretical models in the importance assigned to terms of trade shocks. I contribute to this literature by showing that commodity price shocks are relevant sources of business cycle fluctuations in emerging countries, explaining more than 20 percent of movements in output and more than 30 percent of movements in investment in these economies. Additionally, contrary to some previous studies, I find that the response of real activity to commodity price shocks is similar in the panel VAR and in the theoretical model. I also show that it is important to consider commodity prices instead of the usual terms of trade indices based on unit values, because these indices are subject to several biases and endogeneity issues that are mitigated when we use the former. Finally, I find that the inclusion of commodity price shocks dampens a lot the contribution of interest rate shocks, which were previously found to be crucial to account for emerging economies' business cycles.

There are also some works that focus specifically on commodity price shocks as I do. Céspedes and Velasco (2012), for example, provide empirical evidence using commodity price boom and bust episodes that commodity price shocks have a significant impact on output and investment dynamics and that the impact of those shocks on investment tends to be larger for economies with less developed financial markets, a result in line with what I find in this work. Charnavoki and Dolado (2014) follow Kilian (2009) to identify the main global shocks driving world commodity prices using a dynamic factor model framework and find that a rise in commodity prices unambiguously generates a positive effect on external balances and commodity currency effects, but that a Dutch disease effect at business cycle frequencies in the Canadian manufacturing sector is only detected when the commodity price increase is related to a negative global commodity-specific shock. Collier and Goderis (2012) use a panel error correction methodology and show that commodity price booms have unconditional positive short-term effects on output, but non-agricultural booms in countries with poor governance have adverse long-run effects which dominate the short-term gains. Fernández, González, and Rodriguez (2015) embed a commodity sector into a multi-country business cycle model of small emerging market economies and find that the estimated model gives an important role to commodity prices when accounting for aggregate dynamics. Finally, Fornero, Kirchner, and Yany (2016) also study the effects of commodity price shocks in small open commodity-exporting economies using both a structural VAR and a theoretical model and find expansionary effects of these shocks driven by the positive responses of commodity investment that spill over to non-commodity sectors. I contribute by showing that taking into account explicitly the role of credit frictions in small open economies helps to account for the different effects of commodity price shocks among advanced and emerging economies.

Financial Frictions in Emerging Economies. I also contribute to the literature that studies the role of financial frictions in emerging economies. García-Cicco, Pancrazi, and Uribe (2010) show that the presence of international financial frictions are key to account for observed aggregate dynamics in developing countries, especially the downward-sloping autocorrelation function of the trade balance-to-output ratio, the excess volatility of consumption, the high volatility of investment, and a volatility of the trade balance-to-output ratio comparable to that of output growth. Gertler, Gilchrist, and Natalucci (2007) build a small open economy model with a financial accelerator mechanism and show that it accounts for roughly half of the decline in economic activity in a a quantitative exercise aimed at replicating the key features of the South Korean experience during the Asian financial crisis of 1997/98. Martins and Salles (2011) build a small open economy model with the presence of two imperfect credit markets and calibrate it to Brazilian data to assess different types of credit policies implemented during the Global Financial Crisis. They find that these policies raised GDP but their welfare effects depend on how they are funded. Finally, Fernández and Gulan (2014) embed a financial accelerator into a business cycle model of a small open economy and estimate it on a panel dataset for emerging economies that merges macroeconomic and financial data to explain the countercyclicality of interest rates, a feature that is usually hard to match in traditional models, where the interest rate is either acyclical or procyclical.

Balance Sheet Mismatches and Cross-border Lending. I also evaluate specifically the role of balance sheet mismatches in banks in the transmission of external shocks. Eichengreen and Hausmann (1999) argue that original sin, the fact that the domestic currency cannot be used to borrow abroad or borrow long term leads all domestic investments to have either a currency mismatch or a maturity mismatch. Moreover, this feature is especially important in emerging markets, where the domestic capital markets are underdeveloped. Eichengreen, Hausmann, and Panizza (2007) show that distinguishing among original sin and debt intolerance with currency mismatches is important as the problems with which these approaches deal are analytically different. They also argue that although Chile's institutions are strong, its performance resembled much more that of Latin America than that of Australia, which supports the approach I use in this paper in splitting the countries into emerging and advanced economies regardless of their fiscal and monetary policy frameworks. Choi and Cook (2004) examine the quantitative implications of currency mismatches in banks' balance sheets for the conduct of monetary policy in emerging economies and for the dynamic propagation of macroeconomic shocks in an open economy and find that a monetary policy that fixes the exchange rate to stabilize bank balance sheets offers greater macroeconomic stability than a floating exchange rate policy represented by an inflation-targeting interest rate rule to offset the real effects of sticky prices. Finally, Hahm, Shyn, and Shin (2013) show that in a lending boom, when credit expansion outstrips the pool of available retail deposits, banks turn to other sources of funding to support their credit growth, typically from other banks operating as wholesale lenders in the capital market. They also find that various measures of noncore liabilities, and especially liabilities to the foreign sector, serve as a good measure of the vulnerability to a crisis. Thus, if the commodity boom leads to a strong increase in these foreign liabilities, it would make these economies more vulnerable to external shocks that could lead to a collapse in the value of the currency and a credit crisis where lending rates rise sharply.[5]

I contribute to these last two branches of the literature by developing a framework to evaluate quantitatively four commonly proposed transmission channels through which financial frictions can amplify commodity price shocks (namely the country interest rate, balance sheet mismatches, the financial accelerator and working capital constraints) and showing that the financial accelerator and balance sheet mismatches in the banking sector don't have a relevant quantitative amplification effect for commodity price shocks despite the recent attention devoted to these channels. Instead, the bulk of the differences among advanced and emerging economies are accounted for by the differences in the response of the country interest rate to these shocks and different working capital constraints faced by firms.

5. The recent experience of several emerging and advanced small open commodity exporters seems to validate this mechanism.

1.3 Panel VAR

I first estimate a structural panel VAR for emerging and advanced economies to evaluate the effects of commodity price shocks. The central finding of this section is that commodity price shocks are relevant sources of business cycles in small open commodity producers and have stronger effects on emerging economies with respect to real activity (output and investment), credit and country interest rates.

1.3.1 Data and Panel VAR Specification

My empirical model takes the form of a first-order VAR:

$$Ay_{i,t} = \eta_i + \sum_{k=1}^{p} B_k y_{i,t-k} + \epsilon_{i,t}$$

where η_i is a country fixed effect, i denotes countries and t denotes time period and

$y_{i,t} = [yf_{i,t}, yh_{i,t}]$

$yf_{i,t} = [r_t^{US}, pcm_{i,t}], yh_{i,t} = [gdp_{i,t}, inv_{i,t}, tby_{i,t}, crt_{i,t}, r_{i,t}, reer_{i,t}]$

r^{US} denotes the real U.S. interest rate, pcm denotes the country specific real commodity export price, gdp denotes real gross domestic product, inv denotes real gross fixed capital formation, tby denotes the trade balance to output ratio, crt denotes real credit volume to the non-financial private sector, r denotes the country specific interest rate and $reer$ denotes the real exchange rate. All variables are log deviations from a log-linear and a log-quadratic trend with the exception of the trade balance to output ratio and the interest rates, which are detrended in levels. I also remove the sample mean after detrending for each variable separately. I estimate 2 panel VARs, one for advanced economies (Australia, Canada, New Zealand and Norway) and the other for emerging economies (Argentina, Brazil, Chile, Colombia, Peru and South Africa) for the period 1994:Q1-2013:Q4. The countries selected have commodities representing more than 30% of total exports, well developed financial markets and at least 15 years of data. The data sources are listed in the Appendix.

One departure from the literature that evaluates the effects of terms of trade shocks is that I prefer to use a constructed real commodity export price instead of the ratio of export and import unit value indices, which is the usual measure of terms of trade. The reasons to do that are four. First, Silver (2009) documents several reasons for biases in unit value indices and finds that the discrepancies between unit value indices and price indices can be substantial and even have the wrong sign, especially for heterogenous products, which lead me to focus only on homogeneous commodity product exports.[6] Second, unit values that consider a broad range of products are more likely to be endogenous with respect to country-specific shocks than global commodity prices. Third, as noted by Chen and Rogoff (2003), the presence of nominal rigidities and incomplete pass-through make proper identification when we use the usual terms of trade index close to impossible because these rigidities prevent these measures from adequately incorporating contemporaneous shocks that induce immediate effects on the exchange rate, which are important to account for the real effects of commodity price shocks. Fourth, I do not divide the commodity export price by a commodity import price index because commodity imports represent on average less than 3% of GDP for my sample countries. Moreover, a considerable share of these imports is related to energy products, which have their fluctuations smoothed in most of sample countries through taxes and subsidies, as we can see in Figure 1.3, and thus their price changes are not fully transmitted to the real economy.[7]

6. The sources of bias are (i) the increased product differentiation, which aggravates the bias due to compositional quality mix changes; (ii) the lack of ways for dealing with quality change, temporarily missing values, and seasonal goods with unit value indices; (iii) the increase in trade in services coupled with the lack of customs data for many sorts of service products; (iv) the impossibility of dealing appropriately with "unique" goods such as ships with customs data and unit value indices; and (v) when outlier detection and deletion is automatic and badly applied, such deletions run the risk of missing large price catch-ups due to the stickiness of many price changes.

7. Di Bella et al. (2015) documents that for the Latin American countries in my sample there is either an ad hoc price-setting mechanism (Argentina and Brazil) or the presence of a stabilization fund which smooths price variations (Colombia, Chile and Peru).

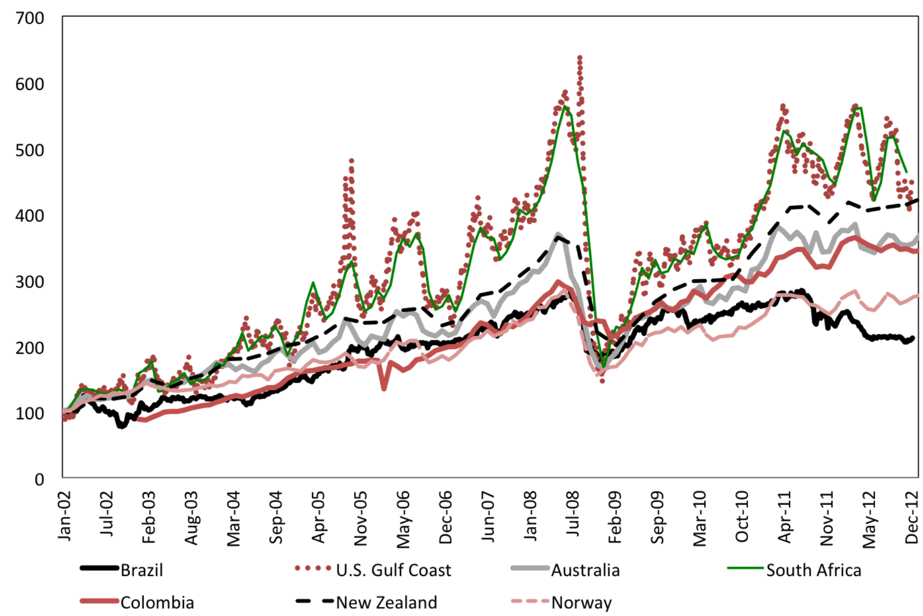

Figure 1.3: Gasoline Prices - US$/Gallon

Real commodity export prices for each country are calculated following Deaton and Miller (1996) and Chen and Rogoff (2003). See the Appendix for details about their construction. Table 1.1 shows the commodity exports profile for the countries in the sample and Figure 1.4 plots the time series for real commodity export prices. As we can see, although there is some dispersion inside the two groups, their average profile is similar with respect to commodity exports as a share of total exports and share of GDP. Moreover, energy products are more relevant for advanced than emerging economies while the opposite is true for metals and agricultural products. Finally, all prices have an upward trend beginning in the early 2000s and are highly correlated.

Table 1.2 shows business cycle statistics for sample countries, averaging over country-specific moments for each of the groups. As expected, all variables are more volatile in emerging than in advanced economies. Moreover, real activity (output and investment) and real exchange rates are positively correlated with commodity prices for both groups. Consistent with previous work, the country interest rate and the trade balance-to-gdp ratio are countercyclical in emerging economies and procyclical and

	Share of Exports	Share of GDP	Main Products
		Emerging	
Argentina	49%	6.3%	Soybeans (41%), Crude Oil (12%), Maize (8.9%)
Brazil	44%	4.4%	Soybeans (22%), Iron Ore (17%), Sugar (9%)
Chile	64%	18.0%	Copper (72%), Fish (9%), Wood (7%)
Colombia	55%	7.5%	Crude Oil (45%), Coal (19%), Coffee (18%)
Peru	60%	11.0%	Copper (34%), Gold (29%), Zinc (11%)
South Africa	30%	6.3%	Coal (23%), Platinum (21%), Iron Ore (10%)
Average	50%	8.9%	
		Advanced	
Australia	63%	10.0%	Coal (21%), Iron Ore (15%), Aluminum (10%)
Canada	30%	8.7%	Crude Oil (25%), Wood (18%), Natural Gas (16%)
New Zealand	33%	7.2%	Wood (21%), Lamb (20%), Beef (16%)
Norway	67%	21.3%	Crude Oil (59%), Natural Gas (21%), Fish (7%)
Average	49%	11.2%	

Note: The data are the simple average from annual trade data for SITC level 4 groups provided by UN COMTRADE from 1994-2013. The number in parenthesis is the share of each product in total commodity exports for each country.

Table 1.1: Country Commodity Exports Profile

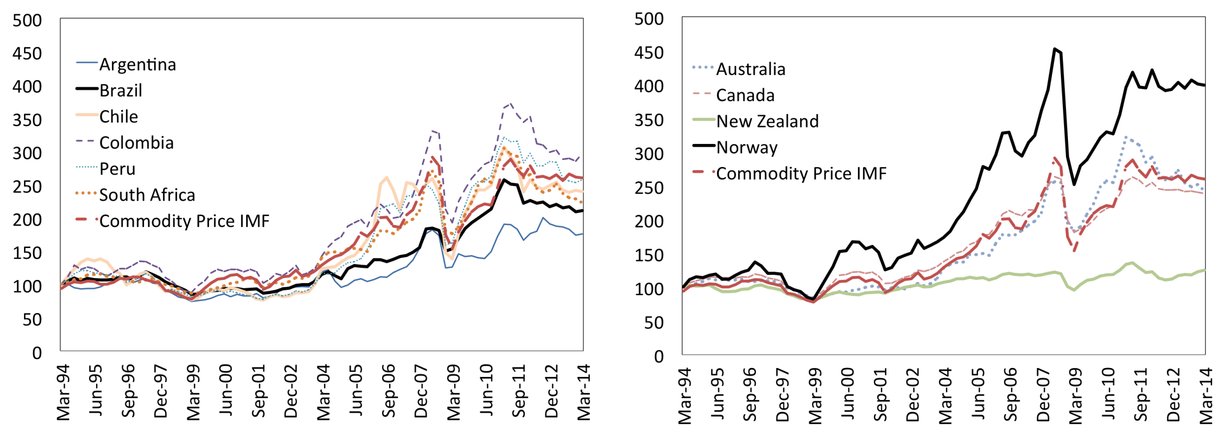

Figure 1.4: Real Commodity Export Prices (1994 = 100)

acyclical, respectively, for advanced economies. Finally, the country interest rate has a positive comovement with commodity prices in emerging economies and a negative comovement in advanced economies, a fact that motivates the inclusion of commodity prices in the country interest rate equation in the theoretical framework.

I identify the panel VAR by a simple recursive structure, imposing that the matrix A is lower triangular. Moreover, I assume that foreign variables are completely exogenous

	Emerging			Advanced		
	σ_X	$\rho(X_t, PCM_t)$	$\rho(X_t, Y_t)$	σ_X	$\rho(X_t, PCM_t)$	$\rho(X_t, Y_t)$
Y	0.03	0.50	1.00	0.01	0.23	1.00
I	0.11	0.44	0.82	0.07	0.41	0.68
TBY	2.4%	0.18	-0.40	1.7%	0.25	-0.06
Crt	0.13	-0.09	0.47	0.04	0.08	0.28
R_{US}	0.01	0.06	0.35	0.01	0.08	0.28
PCM	0.15	1.00	0.50	0.12	1.00	0.23
R	0.03	-0.23	-0.23	0.01	0.23	0.36
REER	0.11	0.23	0.48	0.06	0.52	0.15

Note: The data are the simple average of the indicators for the Emerging (Argentina, Brazil, Chile, Colombia, Peru and South Africa) and Advanced (Australia, Canada, New Zealand and Norway) main commodity exporters. The data sources are listed in the Appendix. The data are sampled quarterly from 1994:Q1-2013:Q4. The columns labeled Y, I, TBY, Crt, R_{US}, PCM, R and REER refer, respectively, to detrended output, investment, trade balance-to-gdp ratio, real credit, US real interest rate, real commodity export price, country real interest rate and real effective exchange rate.

Table 1.2: Business Cycle Statistics

and that real commodity export prices have no effect on the U.S. interest rate.[8] The assumption that commodity price shocks are unrelated to home variables relies on the fact that, at least at business cycle frequencies, commodity price fluctuations are typically more sensitive to short-term demand imbalances. Moreover, with the exception of Chile, which is the world's largest copper producer, and South Africa, a big exporter of precious metals, the countries in the sample have commodity exports distributed over a fairly diffuse set of products and, at least for their main export products, have considerable competition from other countries. Additionally, for Chile and South Africa, Chen, Rogoff, and Rossi (2010) show that the exogeneity assumption holds using the Hausmann test for endogeneity.[9] Finally, innovations in the U.S. interest rate have a contemporaneous effect on the real commodity export prices to take into account the phenomenon of financialization of commodity markets (see for example Cheng and Xiong (2014)).

I use the least square dummy variable estimator to estimate the panel VAR for each

8. Relaxing this assumption does not change the main results.
9. Jacks and Stuermer (2015) also find that demand shocks strongly dominate supply shocks as the main drivers of metal and agricultural commodity prices.

group. As $T >>> N$, the LSDV strategy is preferred to GMM estimators as it has better finite sample properties and efficiency, especially if the degree of cross-section to time series variation is big. Also, with T large, Nickel (1981) critique regarding the bias of the LSDV estimator is less important. I use the Akaike Information Criteria (AIC) to select the lag length and get p = 2 as optimal. I calculate the error bands using bootstrap methods.

1.3.2 Main Results

Figure 1.5 shows the impulse response functions for a 10% positive shock in commodity prices in both advanced and emerging economies. Commodity price shocks have a much larger effect on output, investment and real credit in emerging economies while effects on the trade balance and real exchange rate are similar. Finally, the effects on the country specific real interest rate are also significantly negative and much stronger for emerging economies.

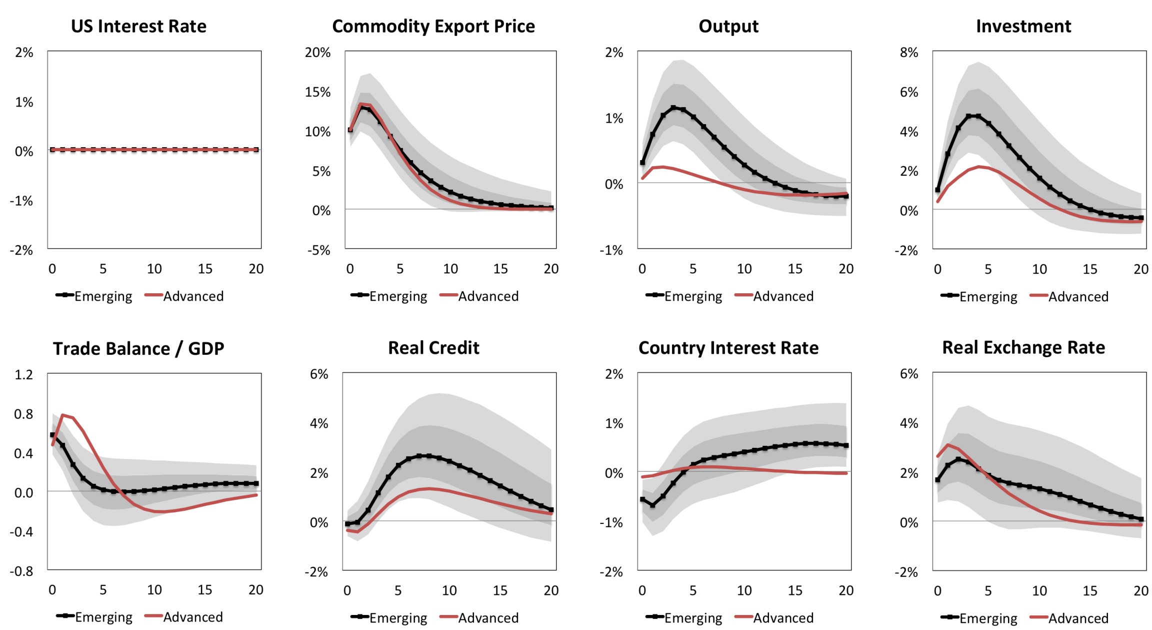

Figure 1.5: Impulse response to a 10% commodity export price shock.

Note: Marked black (solid red) lines show point estimates of impulse responses for emerging (advanced) economies; and 68% and 95% confidence bands are depicted with dark-gray and light-gray shaded areas, respectively. Bootstrap confidence bands are based on 10,000 repetitions.

The impulse responses for a 2% positive shock in the country-specific real interest rate are shown in Figure 1.6.[10] The effects on emerging and advanced economies are as expected, with the exception of output in advanced economies, which shows a small increase after the shock. Again, the effects on emerging economies are much stronger for the same size of shocks, except for the trade balance, where the effect on advanced economies is bigger, and the real exchange rate, where we see a depreciation in emerging economies and an appreciation in advanced economies. This last result might be related to the fact that increases in country specific interest rates in emerging economies are usually due to capital outflows, which also depreciate the exchange rate, while in advanced economies they are mainly due to monetary policy tightening, which attracts capital flows. This fact might also explain why we see an initial increase in investment and the small increase in output in these economies.

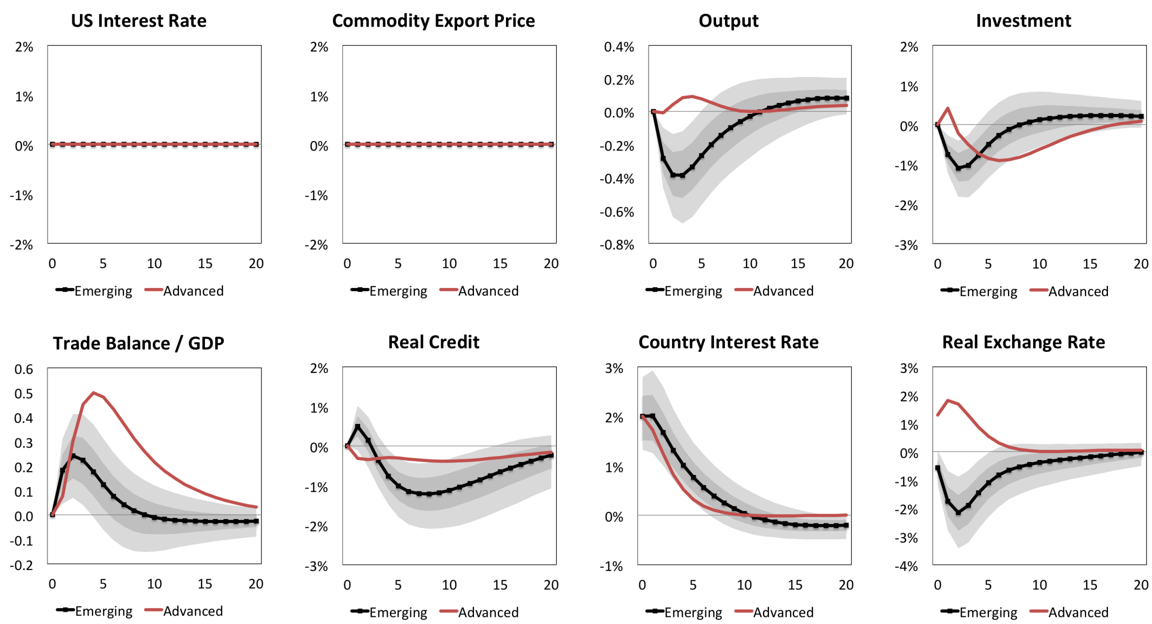

Figure 1.6: Impulse response to a 2% country-specific interest rate shock.

Note: Marked black (solid red) lines show point estimates of impulse responses for emerging (advanced) economies; and 68% and 95% confidence bands are depicted with dark-gray and light-gray shaded areas, respectively. Bootstrap confidence bands are based on 10,000 repetitions.

10. The standard deviation of the emerging economies' country specific interest rate is close to 2%. I use the same shock size for advanced economies to be able to compare the results.

To understand the contribution of each shock for different variables, I perform a variance decomposition of the forecast errors. Figure 1.7 shows the results. Shocks to real commodity export prices and the country-specific real interest rate are more important for real output and investment in emerging economies. According to my estimates, innovations in real commodity export prices are responsible for about 23% of movements in aggregate output in emerging economies and about 7% in advanced economies, while shocks to the country-specific real interest rate orthogonal to commodity price shocks are responsible for about 5% of movements in emerging economies and less than 1% in advanced economies. For real fixed investment, commodity export price innovations are responsible for around 32% of fluctuations in emerging economies and about 15% in advanced economies, while shocks to the country-specific real interest rate are responsible for about 2% of movements in emerging economies and about 1% in advanced economies. Taking these two results together, external shocks explain about 28% of output fluctuations and more than 30% of investment fluctuations in emerging economies, while about only 8% of output fluctuations and 17% of investment fluctuations in advanced economies, illustrating the much bigger importance of external shocks for the former economies. Moreover, including commodity export prices considerably reduces the contribution of country-specific interest rate shocks to fluctuations in emerging economies when compared to previous work. Neumeyer and Perri (2005) and Uribe and Yue (2006), for example, find that interest rate shocks explain around 30% of movements in emerging economies aggregate activity at a business cycle frequency. This indicates that, at least for commodity exporters, when commodity price shocks are omitted from the analysis the country interest rate shocks capture their effects, leading to an overestimation of their importance for business cycle fluctuations.

In the next section, I present the structural model to evaluate more directly the channels that can explain these results.

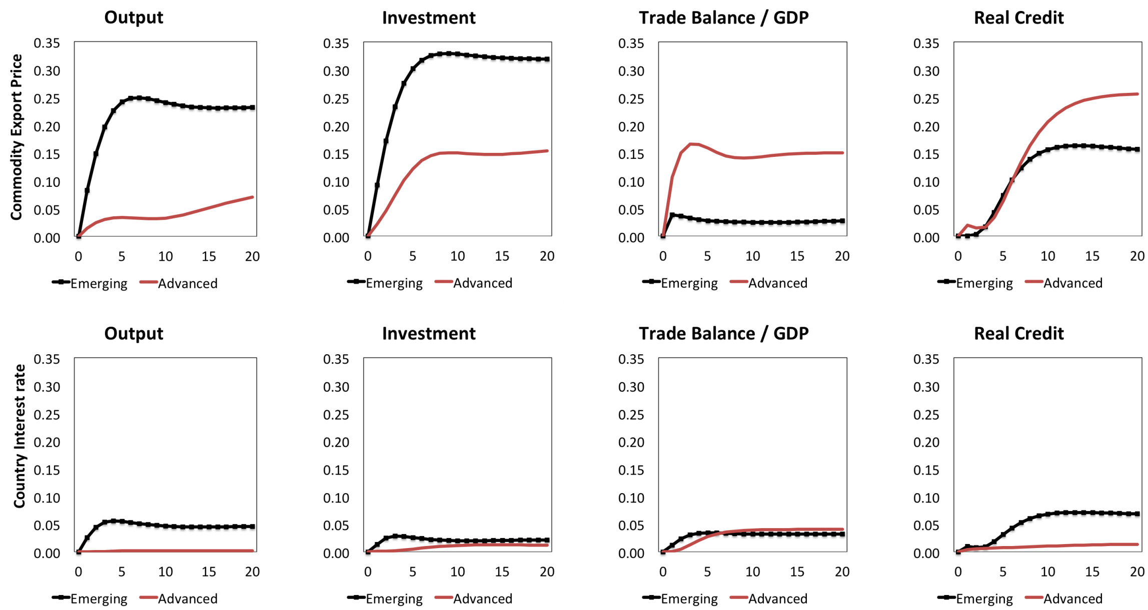

Figure 1.7: Forecast error variance decomposition at different horizons.

Note: Marked black (solid red) lines show point estimates of forecast error variance decomposition for emerging (advanced) economies for the real commodity export price (first row) and country-specific real interest rate (second row) at different horizons.

1.4 Theoretical Framework

In this section I present a model to evaluate the contribution of different financial frictions to the transmission of commodity price shocks. The theoretical framework consists of a small open economy version of a dynamic stochastic model with a financial sector similar to the one proposed in Gertler and Karadi (2011). I enrich the model in several dimensions: (i) I consider 3 different sectors (tradable final goods, nontradable goods and intermediate commodities that can be either used in the local production or exported) that are subject to independent shocks; (ii) the country interest rate can be affected by commodity prices either directly or indirectly through their effects on foreign indebtedness motivated by the results in the panel VAR analysis; (iii) I have working capital constraints for firms, which lead to a wedge in firms' decisions to hire labor and invest, and which transmit interest rate changes to the real economy; (iv) banks get funds from international lenders, subject to a leverage constraint and denominated in tradable units; and (v) banks lend to firms in nontradable units, giving rise to a mismatch in their balance sheets, which interacts with the leverage constraint to amplify the shocks. The leverage constraint arises due to an agency problem, which leads banks to be limited in their capacity to get funds from abroad. When this constraint is binding, credit to the non-financial private sector is limited. In this environment, a positive commodity price shock that might lead to a decrease in the interest rate for foreign borrowing and an increase in the relative price of nontradables would strengthen the bank's balance sheet and consequently allow them to expand borrowing from international investors and lending to the productive sector, amplifying the effect of the shock and transmitting it to the whole economy.

1.4.1 Households

Households are composed of a constant fraction f of workers and $(1-f)$ of bankers. Workers supply labor to firms in exchange for wages while bankers manage financial intermediaries and transfer net earnings to the household. There is perfect insurance between household members. The consumption basket is a CES aggregator with elasticity of substitution μ between tradable c_t^T and nontradable goods c_t^N:

$$c_t \equiv A(c_t^T, c_t^N) = [\chi(c_t^T)^{1-1/\mu} + (1-\chi)(c_t^N)^{1-1/\mu}]^{\frac{1}{1-1/\mu}}$$

Households have preferences described by a utility function similar to the one defined in Greenwood, Hercowitz, and Huffman (1988) with the addition of internal habit formation as can be seen below:

$$U(c_t, c_{t-1}, h_{CM,t}, h_{T,t}, h_{N,t}) = \frac{\left(c_t - bc_{t-1} - \frac{h_{CM,t}^{\omega^{CM}}}{\omega^{CM}} - \frac{h_{T,t}^{\omega^T}}{\omega^T} - \frac{h_{N,t}^{\omega^N}}{\omega^N}\right)^{1-\sigma} - 1}{1-\sigma} \tag{1.1}$$

where $\sigma > 0$ is the coefficient of relative risk aversion, $b \in [0, 1)$ governs the degree of internal habit and $(\omega^{CM}, \omega^{T}, \omega^{N})$ determine the Frisch elasticity of labor supply for each sector. In the absence of habit formation, GHH preferences eliminate the wealth effect on labor supply. Consequently, if b is small, anticipated future income does not affect current labor supply, which will depend mainly on the current wage.

Households are also the owners of firms, receiving all their net profits, and can borrow directly from abroad in international markets without any frictions. Thus, the period-by-period budget constraint of households in terms of numeraire tradable final goods is given by

$$c_t^T + p_t^N c_t^N + R_{t-1}^* d_{t-1}^{*H} = d_t^{*H} + \sum_{j=\{T,N,CM\}} \left[w_{j,t} h_{j,t} + \pi_t^j \right] + \pi_t^B \tag{1.2}$$

where d_t^{*H} denotes the stock of one-period debt acquired in period t and due in period t+1, R_t^* is the interest rate charged for foreign borrowing, $w_{j,t}$ is the wage and π_t^j is the net cash flow received from firms on each sector j, and π_t^B are the profits sent by bankers to the household.

Finally, households are subject to a no-Ponzi scheme constraint:

$$\lim_{m \to \infty} E_t \frac{d_{t+m+1}^h}{\Pi_{s=0}^m R_{t+s}^*} \leq 0 \tag{1.3}$$

I assume that labor supply is chosen one period in advance, motivated by the fact that output barely moves initially after a commodity price shock in the panel VAR analysis. Thus, the consumption of tradables c_t^T and nontradables c_t^N, debt holdings d_t^{*H} and labor supply $h_{j,t+1}$ are given by maximizing the discounted expected future flow of utility using a subjective discount factor $\beta \in (0, 1)$ subject to the budget constraint and the no-Ponzi scheme constraint. Denoting the Lagrange multiplier associated with the budget constraint as λ_t, the first order conditions of the household's problem are

$$\lambda_t = U_t' A_1(c_t^T, c_t^N) - b\beta E_t[U_{t+1}' A_1(c_{t+1}^T, c_{t+1}^N)] \tag{1.4}$$

$$p_t^N = \frac{U_t' A_2(c_t^T, c_t^N) - b\beta E_t[U_{t+1}' A_2(c_{t+1}^T, c_{t+1}^N)]}{U_t' A_1(c_t^T, c_t^N) - b\beta E_t[U_{t+1}' A_1(c_{t+1}^T, c_{t+1}^N)]} \tag{1.5}$$

$$E_t[\lambda_{t+1} w_{CM,t+1}] = E_t[U_{t+1}' h_{CM,t+1}^{\omega^{CM}-1}] \tag{1.6}$$

$$E_t[\lambda_{t+1} w_{T,t+1}] = E_t[U_{t+1}' h_{T,t+1}^{\omega^{T}-1}] \tag{1.7}$$

$$E_t[\lambda_{t+1} w_{N,t+1}] = E_t[U_{t+1}' h_{N,t+1}^{\omega^{N}-1}] \tag{1.8}$$

$$\lambda_t = \beta R_t^* E_t \lambda_{t+1} \tag{1.9}$$

where

$$U_t' = \left(c_t - \frac{h_{CM,t}^{\omega^{CM}}}{\omega^{CM}} - \frac{h_{T,t}^{\omega^{T}}}{\omega^{T}} - \frac{h_{N,t}^{\omega^{N}}}{\omega^{N}} \right)^{-\sigma}$$

$$A_1(c_t^T, c_t^N) = \chi \left(\frac{c_t}{c_t^T} \right)^{\frac{1}{\mu}}$$

$$A_2(c_t^T, c_t^N) = (1-\chi) \left(\frac{c_t}{c_t^N} \right)^{\frac{1}{\mu}}$$

1.4.2 Commodity and Final Non-Tradable Goods Producers

Commodity and final non-tradable goods producers have a Cobb-Douglas production function that uses capital and labor as inputs. Following Uribe and Yue (2006), I assume that firms face a working capital constraint and thus, for each unit of wage payments and investment, firms must hold η units of a non-interest bearing asset, denoted m_t^j. Firms can borrow from banks at a rate R_t to cover working capital expenses. Firms also choose investment one-period in advance, motivated by the fact that investment barely moves initially after a commodity price shock in the panel VAR analysis. Finally, firms are subject to investment adjustment costs and a no-Ponzi scheme constraint:

$$\lim_{m\to\infty} E_t \frac{d^j_{t+m+1}}{\Pi_{s=0}^m R^j_{t+s}} \leq 0 \tag{1.10}$$

Firms discount their profits using the household's marginal utility of wealth because they are owned by them. The firm's problem is thus given by

$$\max_{k_{j,t+1}, i_{j,t+1}, h_{j,t}, d^j_t, m^j_t} E_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \pi^j_t \tag{1.11}$$

subject to

$$\pi^j_t = p^j_t y^j_t - i_{j,t} - w_{j,t} h_{j,t} - p^N_t (m^j_t - m^j_{t-1}) + p^N_t \left(d^j_t - R_{t-1} d^j_{t-1} \right) \tag{1.12}$$

$$y^j_t = a_{j,t} k^{\alpha^j}_{j,t} h^{1-\alpha^j}_{j,t} \tag{1.13}$$

$$k_{j,t+1} = (1-\delta) k_{j,t} + i_{j,t} \left(1 - \frac{\phi^j}{2} \left(\frac{i_{j,t}}{i_{j,t-1}} - 1 \right)^2 \right) \tag{1.14}$$

$$p^N_t m^j_t \geq \eta^j [w_{j,t} h_{j,t} + i_{j,t}] \tag{1.15}$$

where $j = \{N, CM\}$ represents the firm's sector, where N stands for the final non-tradable goods sector and CM for the commodity goods sector.

The first order conditions of the firm's problem are

$$(1-\alpha^j) \frac{p^j_t y^j_t}{h_{j,t}} = w_{j,t} (1 + \eta^j \xi^j_t) \tag{1.16}$$

$$\lambda_t q_{j,t} = \beta E_t \left\{ \lambda_{t+1} \left[q_{j,t+1} (1-\delta) + \alpha^j \frac{p^j_{t+1} y^j_{t+1}}{k_{j,t+1}} \right] \right\} \tag{1.17}$$

$$E_t \left\{ \lambda_{t+1} q_{j,t+1} \left[1 - \frac{\phi^j}{2} \left(\frac{i_{j,t+1}}{i_{j,t}} - 1 \right)^2 - \phi^j \left(\frac{i_{j,t+1}}{i_{j,t}} \right) \left(\frac{i_{j,t+1}}{i_{j,t}} - 1 \right) \right] \right\} +$$

$$\beta E_t \left\{ \lambda_{t+2} q_{j,t+2} \phi^j \left(\frac{i_{j,t+2}}{i_{j,t+1}} \right)^2 \left(\frac{i_{j,t+2}}{i_{j,t+1}} - 1 \right) \right\} = E_t[\lambda_{t+1}(1 + \eta^j \zeta^j_{t+1})] \quad (1.18)$$

$$(1 - \zeta^j_t) = E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{p^N_{t+1}}{p^N_t} \right) \quad (1.19)$$

$$E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{p^N_{t+1}}{p^N_t} R_t \right) = 1 \quad (1.20)$$

Combining the last two equations we get

$$\zeta^j_t = \left(\frac{R_t - 1}{R_t} \right) \quad (1.21)$$

which shows that the working capital constraint introduces a distortion that elevates the effective cost of labor and investment for each sector and makes optimal production decisions depend on the interest rate charged by banks.

1.4.3 Final Tradable Goods Producers

Besides using capital and labor as inputs, final tradable goods producers also have an additional input, commodity intermediate goods. I assume again that firms have a Cobb-Douglas production function, choose investment one period in advance and face investment adjustment costs and a working capital constraint, and thus the firm's problem is given similarly by

$$\max_{k_{T,t}, i_{T,t+1}, h_{T,t}, d^T_t, m^T_t} E_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \pi^T_t \quad (1.22)$$

subject to

$$\pi_t^T = p_t^T y_t^T - i_{T,t} - w_t h_{T,t} - p_t^{CM} cm_t - p_t^N (m_t^T - m_{t-1}^T) + p_t^N \left(d_t^T - R_{t-1}^T d_{t-1}^T \right) \tag{1.23}$$

$$k_{T,t+1} = (1-\delta) k_{T,t} + i_{T,t} \left(1 - \frac{\phi^T}{2} \left(\frac{i_{T,t}}{i_{T,t-1}} - 1 \right)^2 \right) \tag{1.24}$$

$$y_t^T = a_{T,t} k_t^{\alpha^T} cm_t^{\gamma^T} h_t^{1-\alpha^T-\gamma^T} \tag{1.25}$$

$$p_t^N m_t^T \geq \eta^T [w_t h_{T,t} + p_t^{CM} cm_t + i_{T,t}] \tag{1.26}$$

The first order conditions of the firm's problem are then

$$(1-\alpha^T-\gamma^T) \frac{y_t^T}{h_t^T} = w_t (1 + \eta^T \xi_t^T) \tag{1.27}$$

$$\gamma^T \frac{y_t^T}{cm_t^T} = p_t^{CM} (1 + \eta^T \xi_t^T) \tag{1.28}$$

$$\lambda_t q_{T,t} = \beta E_t \left\{ \lambda_{t+1} \left[q_{T,t+1} (1-\delta) + \alpha^T \frac{y_{t+1}^T}{k_{T,t+1}} \right] \right\} \tag{1.29}$$

$$\begin{aligned} E_t \left\{ \lambda_{t+1} q_{T,t+1} \left[1 - \frac{\phi^T}{2} \left(\frac{i_{T,t+1}}{i_{T,t}} - 1 \right)^2 - \phi^T \left(\frac{i_{T,t+1}}{i_{T,t}} \right) \left(\frac{i_{T,t+1}}{i_{T,t}} - 1 \right) \right] \right\} + \\ \beta E_t \left\{ \lambda_{t+2} q_{T,t+2} \phi^T \left(\frac{i_{T,t+2}}{i_{T,t+1}} \right)^2 \left(\frac{i_{T,t+2}}{i_{T,t+1}} - 1 \right) \right\} = E_t [\lambda_{t+1} (1 + \eta^T \xi_{t+1}^T)] \end{aligned} \tag{1.30}$$

$$(1 - \xi_t^T) = E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{p_{t+1}^N}{p_t^N} \right) \tag{1.31}$$

$$E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{p_{t+1}^N}{p_t^N} R_t \right) = 1 \tag{1.32}$$

and, as before, combining the two last equations shows that the working capital constraint introduces a wedge that elevates the effective cost of labor, investment and commodity inputs:

$$\xi_t^T = \left(\frac{R_t - 1}{R_t}\right) \tag{1.33}$$

1.4.4 Bankers

In addition to her accumulated net worth, n, a banker can obtain capital from foreign investors, d^{*B}, in the form of one-period non-contingent debt denominated in tradable goods units. The assets held by the banks are loans provided to firms in different sectors in the form of one-period non-contingent debt denominated in non-tradable goods units. As the bank borrows in tradable units and lends in non-tradable units, this gives rise to a mismatch in the bank's balance sheet, which is given by

$$\sum_{j=\{T,N,CM\}} p_t^N d_t^j = n_t + d_t^{*B} \tag{1.34}$$

Intermediaries borrowing at time t pay the non-contingent real gross return R_t^* at $t+1$. Net worth next period is given by the difference between realized returns on assets and payments promised to foreign investors:

$$n_{t+1} = \sum_{j=\{T,N,CM\}} \left(R_t p_{t+1}^N d_t^j\right) - R_t^* d_t^{*B} \tag{1.35}$$

where R_t is the gross return on loans.

Bankers' borrowing from abroad is limited to a multiple $\phi^B - 1$ of their net worth. Combining this borrowing limit with the bank's balance sheet equation, we get the following leverage constraint: [11]

11. This leverage constraint can be motivated by a moral hazard problem as in Gertler and Karadi (2011) where, at the beginning of each period, bankers can choose to divert a fraction λ of their assets and transfer them back to the household of which he or she is a member. This limited enforcement problem introduces an incentive constraint that requires the bank's continuation value to be higher than the value of diverted funds and leads to a leverage constraint similar to what I have here, with the difference that the parameter ϕ^B would be time varying depending on the returns that bankers' earn and the interest rate they pay for foreign lenders.

$$\sum_{j=\{T,N,CM\}} p_t^N d_t^j \leq \phi^B n_t \tag{1.36}$$

As long as the the bank earns a risk adjusted return that is greater than its funding costs, it is optimal for the banker to keep accumulating assets until exiting the business. At any point of time, there is a probability $1-\theta$ that a banker exits the financial sector and becomes a worker, transferring all the accumulated net worth to the household.

Transfers to new bankers amount to the time invariant fraction $\nu^B/(1-\theta)$ of the value of assets of exiting bankers:

$$N_{t+1}^n = \frac{\nu^B}{(1-\theta)}(1-\theta) \sum_{j=\{H,T,N,CM\}} p_{t+1}^N D_t^j \tag{1.37}$$

Aggregate net worth depends on both existing bankers' net worth and the net worth of new bankers. Since a fraction θ of bankers survives each period, the net worth next period is given by

$$N_{t+1} = \theta \left\{ \sum_{j=\{T,N,CM\}} \left[\left(R_t \frac{p_{t+1}^N}{p_t^N} - R_t^* \right) p_t^N D_t^j \right] + R_t^* N_t \right\} + \nu^B \sum_{j=\{T,N,CM\}} p_{t+1}^N D_t^j \tag{1.38}$$

1.4.5 International Capital Markets and Exogenous Processes

I follow Schmitt-Grohé and Uribe (2003) and assume that the economy faces a debt-elastic interest rate premium. Moreover, to capture the effects of commodity prices on the country premium that were found in the panel VAR analysis, I also assume that the interest rate depends on the level of the real commodity export price with respect to its steady state value as follows[12]

12. Bastourre et al. (2013) and Fernández, González, and Rodriguez (2015) show that there is a strong negative comovement between interest rates and commodity prices in emerging economies, which motivates the inclusion of commodity prices directly in the interest rate equation. They also show that this negative association pattern is not only explained by the fact that commodity prices are one of the most relevant fundamentals for commodity exporters' bond spreads but also that reductions in international interest rates and global risk appetite, rises in quantitative global liquidity measures and equity returns, and

$$R_t^* = \bar{R}^* + \psi^D(e^{d_t^* - \bar{d}^*} - 1) + \psi^{CM}(e^{p_t^{CM} - \bar{p}^{CM}} - 1) + \epsilon_t^{r^*} \tag{1.39}$$

where d^* is total foreign debt from both workers and bankers and $\bar{d}^*$ is its steady state value, $\bar{p}^{CM}$ is the steady state value of the real commodity export price and $\epsilon_t^{r^*}$ is a normally distributed shock.

The productivity for each sector is assumed to follow an AR(1) process with normally distributed shocks:

$$log(a_{CM,t+1}) = \rho^{CM} log(a_{CM,t}) + \epsilon_t^{CM} \tag{1.40}$$

$$log(a_{T,t+1}) = \rho^{T} log(a_{T,t}) + \epsilon_t^{T} \tag{1.41}$$

$$log(a_{N,t+1}) = \rho^{N} log(a_{N,t}) + \epsilon_t^{N} \tag{1.42}$$

Finally, the real commodity export price is assumed to be completely exogenous and follows an AR(2) process around its steady state, value with normally distributed shocks:[13]

$$log(p_{t+1}^{CM}) - log(\bar{p}^{CM}) = \rho_1^{PCM} log(p_t^{CM} - log(\bar{p}^{CM})) + \rho_2^{PCM} log(p_{t-1}^{CM} - log(\bar{p}^{CM})) + \epsilon_t^{PCM} \tag{1.43}$$

1.4.6 Market Clearing

To close the model, we have the following market clearing conditions:

1. Goods Market:

$$c_t^N = y_t^N \tag{1.44}$$

US dollar depreciations tend to diminish spreads of emerging economies and strengthen commodity prices simultaneously. This specification captures these effects in a reduced form manner.

13. I use an AR(2) process for the real commodity export price to be coherent with the optimal lag length found in the panel VAR analysis.

$$i_t = i_{CM,t} + i_{T,t} + i_{N,t} \tag{1.45}$$

$$tb_t^T = y_t^T - c_t^T - i_t \tag{1.46}$$

2. Foreign sector

$$tb_t^{CM} = p_t^{CM}(y_t^{CM} - cm_{T,t}) \tag{1.47}$$

$$tb_t = tb_t^T + tb_t^{CM} \tag{1.48}$$

$$d_t^* = d_t^{*H} + d_t^{*B} \tag{1.49}$$

$$ca_t = tb_t - r_t^* d_t^* = d_{t+1}^* - d_t^* \tag{1.50}$$

1.4.7 Equilibrium Conditions and Numerical Solution

The competitive equilibrium is described by a system of nonlinear equilibrium conditions that cannot be solved analytically, so I use perturbation techniques to solve it numerically. The method consists in first solving numerically for the deterministic steady state of the economy when the leverage constraint in the banking sector is always binding, and then performing a first order approximation of the system of equations around this steady state.[14] All the equilibrium conditions and the details of the steady state calculation are shown in the Appendix.

1.4.8 Transmission Channels

It is now useful to describe the mechanism that ties commodity price shocks, financial frictions, and real economic activity. An increase in commodity price shocks is transmitted to the rest of the economy via four distinctive financial channels that are usually studied in the literature. First, if an increase in the price of commodities reduces the interest rate charged by financial intermediaries from firms, this reduction will lead

14. This assumption allows me to use perturbation methods to solve the model. Otherwise, I would have to rely in other solution methods which are more time consuming and thus would make the estimation much more difficult.

to an increase in output and investment because the working capital constraint introduces a wedge in firms decisions to hire labor and invest which depends on the level of the interest rate. I call this channel the ***working capital channel***.

Second, as the banking sector is subject to a leverage constraint, if the net worth of the bank increases after a rise in commodity prices, banks can borrow more from foreign lenders. Consequently, the supply of credit for firms will also expand and the interest rate charged by financial intermediaries will decrease, inducing an expansion in credit and real activity. This is the ***financial accelerator channel***. Third, and related to the previous one, because the price of nontradables increases when commodity prices go up, the value of banks' assets will also rise, which generates an expansion in their net worth as the value of banks' liabilities stays constant. This increase in the net worth interacts with the leverage constraint and spurs additional borrowing from abroad, which leads again to an expansion in output and investment. This is the ***balance sheet mismatch channel***. Figure 1.8 illustrates the interaction between these two channels.

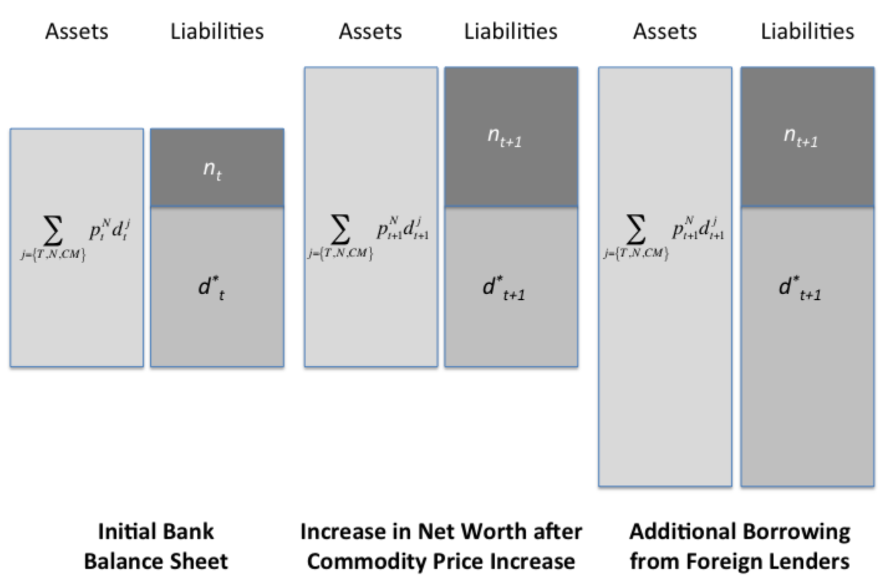

Figure 1.8: Balance sheet mismatch and financial accelerator channels

Fourth, a rise in the price of commodities reduces the country foreign indebtedness through the increase in exports and consequently lowers the country interest rate. Moreover, especially for emerging economies, there is an additional reduction on interest rates due to lower country risk and consequently an increase in capital flows. I call this channel the ***country interest rate channel***.

In the next section I will estimate the model to be able to evaluate which of these four channels are more relevant quantitatively for the transmission of commodity price shocks.

1.5 Quantitative Analysis

The model is estimated using the same dataset used in the Panel VAR and Bayesian methods. First I describe the estimation strategy; and then I present diagnostics regarding model fit and evaluate the estimated model, comparing its properties with the panel VAR estimated for each group of countries and analyzing the transmission mechanism.

1.5.1 Model Estimation

I denote the vector of model parameters by $\theta \in \Theta$. It is useful to partition the parameter vector into $\theta = [\theta_1, \theta_2]$, where θ_1 represents the set of parameters that are calibrated while θ_2 represents the set of parameters that are estimated.

$\theta_1 = [\bar{d}^*, \bar{p}^{CM}, \bar{r^*}, \beta, \mu, \delta, \chi, \sigma, \alpha^{CM}, \alpha^T, \alpha^N, \gamma^T, \omega^{CM}, \omega^T, \omega^N, \nu^B]$

$\theta_2 = [\psi^D, \psi^{CM}, \eta^{CM}, \eta^T, \eta^N, \phi^B, \theta^B, b, \phi^{CM}, \phi^T, \phi^N]$

I choose the calibrated parameters using both long-run data relations from emerging and advanced economies and parameter values that are standard in related business cycle studies. Table 1.3 shows the calibrated parameter values. I set the parameter $\bar{d}^*$ to induce a steady-state value of the trade balance-to-output ratio of 1% for emerging economies and 0% for advanced economies. I set $\bar{p}^{CM}$ to get a steady-state value of the

Parameter	Value	Source/target
Steady-state foreign debt	$\bar{d}^{*} = 0.12$ (0.0)	TB-to-output ratio = 1% (0%)
Steady-state pcm	$\bar{p}^{CM} = 0.69$	TBCM-to-output ratio = 10%
Interest rate	$\bar{r}^{*} = 0.02$ (0.01)	Average value
Discount factor	$\beta = 0.98(0.99)$	$\beta = 1/(1+r^{*})$
At. elasticity of substitution	$\mu = 0.5$	Akinci (2011)
Weight on tradables in CES	$\chi = 0.35$	Share of nontradable output = 50%
In. elasticity of substitution	$\sigma = 2$	Standard value
Labor curvature	$\omega^{CM} = \omega^{T} = \omega^{N} = 1.455$	Standard value
Depreciation rate	$\delta = 2.5\%$	Standard value
Capital share ratio	$\alpha^{N} = 0.25$	Labor share of income = 75%
Capital share ratio	$\alpha^{T} = \alpha^{CM} = 0.35$	Labor share of income = 70%
Commodity input share	$\gamma^{T} = 0.05$	Commodity inputs = 5%
Transfer rate	$\nu^{B} = 0.01$	Small share of total assets
AR1 coefficient *pcm*	$\rho_1 = 1.29(1.32)$	Panel VAR
AR2 coefficient *pcm*	$\rho_2 = -0.40(-0.45)$	Panel VAR
Std *pcm* shock	$\sigma^{pcm} = 0.067(0.053)$	Panel VAR

Table 1.3: Calibrated Parameter Values

commodity exports-to-output ratio of 10%. I set the steady-state interest rate to 1% for advanced economies and 2% for emerging economies and β accordingly as $1/(1+\bar{r}^{*})$ for each group of economies. I set the elasticity of substitution between tradable and nontradable final goods to 0.5, which is in the range found by Akinci (2011). I set the depreciation rate δ at 2.5%, which implies an annual depreciation rate around 10%. I set χ to 0.35 to have a nontradable final goods production-to-output ratio around 50%. The intertemporal elasticity of substitution σ is set to 2 and the labor curvature parameters ω^{CM}, ω^{T} and ω^{N} are set to 1.455, which are fairly standard values. Using the results from Na (2015) and Uribe (1997), the capital share ratios α^{CM} and α^{T} are set to 0.35 while α^{N} is set to 0.25 to get the labor share of income close to 70% in the first two sectors and 75% in the latter, and γ^{T} is set to 0.05. Finally, I set ν^{B} to 1% to make new bankers start with a small share of total assets.[15]

The parameters in θ_2 are estimated using as observables the same set of home

15. I don't estimate this parameter because it is not well identified when it is estimated together with the other banking sector parameters.

variables used in the panel VAR, namely real gross domestic product, real gross fixed capital formation, the trade balance to output ratio, real credit concessions to the non-financial private sector, the country-specific real interest rate and the real effective exchange rate, using the same detrending method. I prefer to use exactly the same data used in the panel VAR analysis to check how closely the model can replicate its results. I also add measurement errors to all observables.

I use the Bayesian methods surveyed in An and Schorfheide (2007) to estimate the vector θ_2, the persistence and standard deviations of the shocks and the standard deviations of the measurement errors. Conditional on the distribution of the exogenous shocks and after computing the first order approximation of the model around the steady state assuming that the banking sector leverage constraint is always binding, the model defines a state space system which generates a likelihood function that can be used to transform prior distributions for the structural parameters into a posterior distribution using the Bayes Theorem. As it is not feasible to characterize the posterior distribution analytically, we have to use computational techniques to generate draws from the posterior and then approximate posterior expectations by Monte Carlo averages. I use a Random Walk Metropolis Hastings algorithm implemented in Schorfheide (2000) to compute the posterior distribution and evaluate the marginal likelihood of the model. I use priors that are standard in the literature for most of the parameters while for the parameters related to the financial frictions I choose very loose and uninformative prior.

Particularly, the coefficients of the country interest rate process (ψ^D, ψ^{CM}) are assumed to follow uniform distributions, with the first ranging from 0.00001 to 0.5, and the second ranging from -0.05 to 0; the working capital constraint parameters $(\eta^{CM}, \eta^T, \eta^N)$, a gamma distribution with mean 2 and standard deviation of 1; the leverage constraint parameter (ϕ^B), an uniform distribution ranging from 2 to 20; the parameter that governs the survival rate of bankers (θ^B), a beta distribution with mean

0.7 and standard deviation of 0.1; the parameter that governs internal habit formation (b), a beta distribution with mean 0.75 and standard deviation of 0.1; the sectoral investment adjustment costs parameters ($\phi^{CM}, \phi^{T}, \phi^{N}$), a gamma distribution with mean 10 and standard deviation of 5; the persistence of the autoregressive processes ($\rho^{CM}, \rho^{T}, \rho^{N}$), a beta distribution with mean 0.5 and standard deviation of 0.2; and the standard errors of the innovations ($\sigma^{r^*}, \sigma^{CM}, \sigma^{T}, \sigma^{N}$), an inverse-gamma distribution with mean 0.1 and a standard deviation of 2. Finally, uniform prior distributions were chosen for the innovations of the measurement errors, restricted to account for at most 10% of the average variance of each corresponding observable time series. Table 1.4 reports the priors with the average of the posterior means for θ_2 for each group of countries and all the prior and posterior plots are in a separate Computational Appendix. Comparing the posterior distributions with the prior distributions we can conclude that the data are informative about all estimated parameters.

1.5.2 Model Fit and Analysis

This subsection analyzes the properties of the model. First, I compare the impulse response functions of the baseline estimation with the ones obtained from the Panel VARs. In general, the impulse responses generated by the model are close to the ones generated by the VARs. Then, I do some counterfactual exercises to evaluate the key channels through which the results are obtained, especially the different responses of emerging and advanced economies to commodity price shocks.

Figures 9-11 show the results for the impulse responses for a 10% positive shock to commodity prices comparing, respectively, the model and the panel VAR results for emerging and advanced economies, and the model results for both groups of countries. Model estimates are computed in two steps: first, I compute the mean posterior IRF for each country; then I take the average across countries for each group.

The model matches well the behavior of most of the variables after the commodity

Parameter	Prior	Para 1	Para 2	Advanced Posterior Mean	Emerging Posterior Mean
ψ^D	Uniform	0.00001	0.50	0.016	0.077
ψ^{CM}	Uniform	-0.05	0	-0.006	-0.014
η^{CM}	Gamma	2.0	1.0	2.9	2.5
η^T	Gamma	2.0	1.0	1.7	1.9
η^N	Gamma	2.0	1.0	1.2	2.1
ϕ^B	Uniform	2.0	20	2.06	2.04
θ^B	Beta	0.70	0.10	0.72	0.75
b	Beta	0.75	0.10	0.46	0.45
ϕ^{CM}	Gamma	10	5	10.6	10.3
ϕ^T	Gamma	10	5	1.8	4.6
ϕ^N	Gamma	10	5	11.3	9.3
ρ^{CM}	Beta	0.50	0.20	0.73	0.88
ρ^T	Beta	0.50	0.20	0.89	0.87
ρ^N	Beta	0.50	0.20	0.82	0.84
σ^{r^*}	Inverse Gamma	0.10	2.0	0.01	0.02
σ^{CM}	Inverse Gamma	0.10	2.0	0.16	0.57
σ^T	Inverse Gamma	0.10	2.0	0.03	0.05
σ^N	Inverse Gamma	0.10	2.0	0.01	0.02

Note: Para 1 and Para 2 are the extreme values for the Uniform distribution; and mean and standard deviation for Beta, Gamma and Inverse Gamma distributions. Posterior statistics are computed using 400,000 draws from the posterior distribution of model's parameters.

Table 1.4: Prior and Posterior Distribution of θ_2

price shock when compared with the results obtained in the panel VAR analysis for both group of countries. Both in the panel VAR and the theoretical model we have stronger responses of output, investment, credit and country interest rate in emerging economies. The key difference between the model and the panel VAR is the behavior of the trade balance in emerging economies, which increases more in the model than in the data; and the real exchange rate in advanced economies, which appreciates more in the panel VAR than in the model. Moreover, output and investment are more persistent in the model than in the data. Finally, credit increases more rapidly in the model than in the panel VAR, which might indicate some type of time-to-lending feature in reality.

The estimated model can then be used to ask which channel is responsible for the different results between emerging and advanced economies. I analyze what happens if

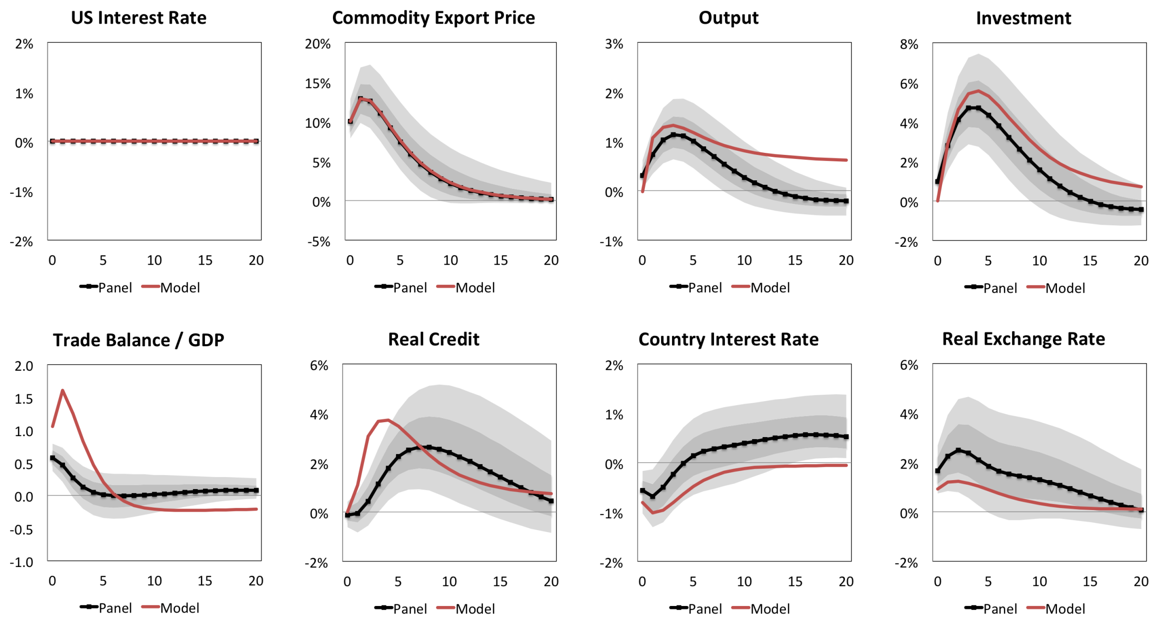

Figure 1.9: Impulse response to a 10% commodity export price shock - Emerging Economies.
Note: Marked black (solid red) lines show point estimates of impulse responses for emerging economies for the panel VAR (model); and 68% and 95% confidence bands for the panel VAR estimates are depicted with dark-gray and light-gray shaded areas, respectively. Bootstrap confidence bands are based on 10,000 repetitions. Model estimates are the average of impulse responses across countries.

(i) there isn't any mismatch in banks balance sheets in emerging countries; (ii) the financial accelerator is not present in the banking sector in emerging economies; and (iii) emerging economies have the same working capital constraints and interest rate processes as the average of the estimates for advanced economies.

Balance sheet mismatch channel. I first recompute the impulse responses eliminating the mismatch in banks' balance sheets by making them lend in tradable units to firms. The results can be seen in Figure 1.12. The impulse responses are almost identical to the baseline scenario, with the exception of the interest rate spread, which increases on impact. Consequently, we can conclude that quantitatively the role of balance sheet mismatches is minor in this environment.

Financial accelerator channel. Now I eliminate the leverage constraint and consequently the entire banking sector, as without the constraint the model is equivalent to one where firms borrow directly from abroad. The impulse responses can be seen in

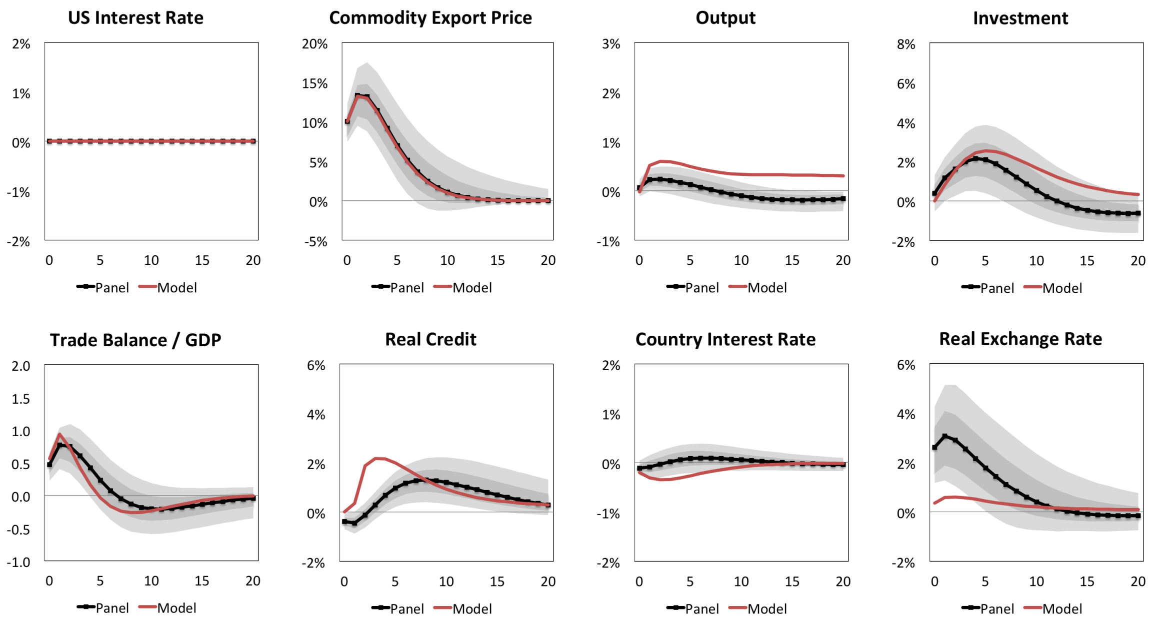

Figure 1.10: Impulse response to a 10% commodity export price shock - Advanced Economies.
Note: Marked black (solid red) lines show point estimates of impulse responses for advanced economies for the panel VAR (model); and 68% and 95% confidence bands for the panel VAR estimates are depicted with dark-gray and light-gray shaded areas, respectively. Bootstrap confidence bands are based on 10,000 repetitions. Model estimates are the average of impulse responses across countries.

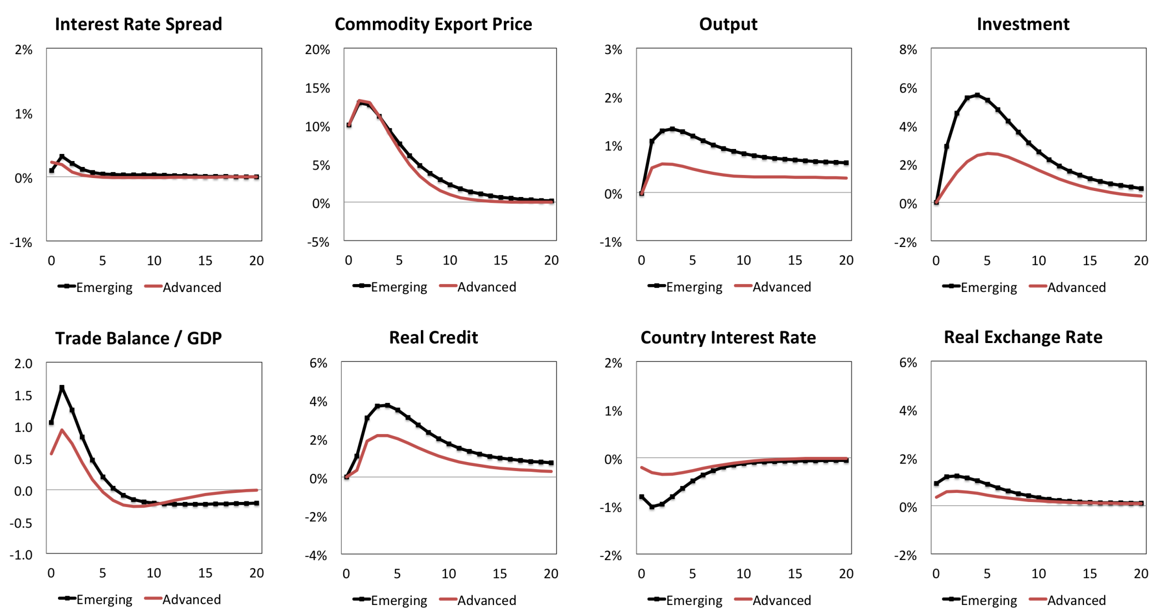

Figure 1.11: Impulse response to a 10% commodity export price shock - Model Comparison.
Note: Marked black (solid red) lines show point estimates of impulse responses for emerging (advanced) economies for the model. Model estimates are the average of impulse responses across countries. Model estimates are the average of impulse responses across countries.

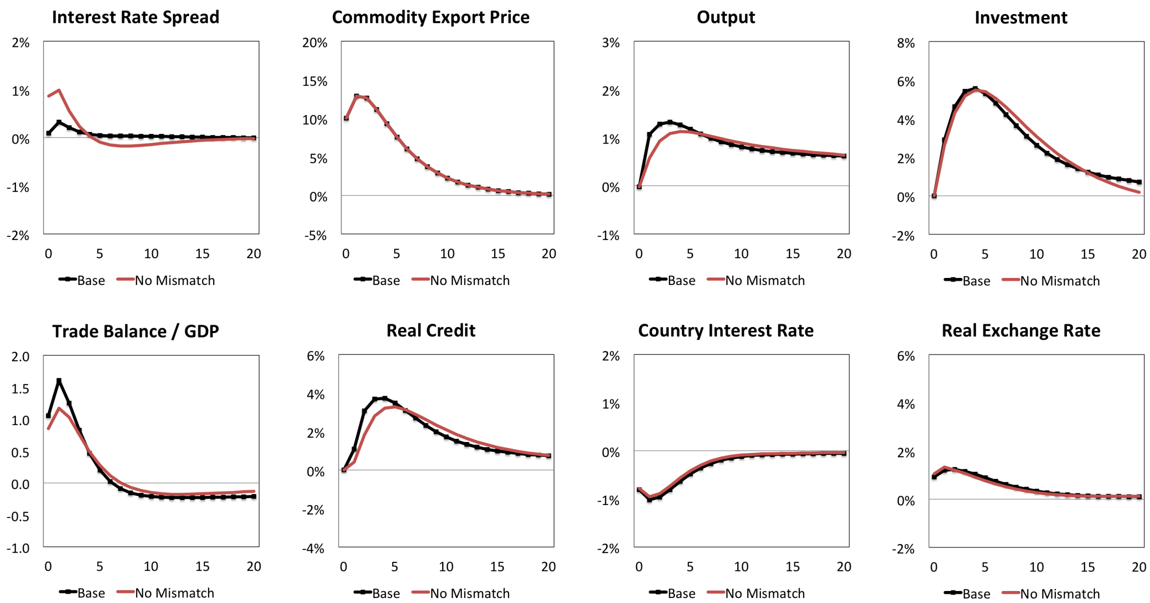

Figure 1.12: Impulse response to a 10% commodity export price shock - No Mismatch.
Note: Marked black (solid red) lines show point estimates of impulse responses for emerging economies for the model in the baseline (alternative) scenario. Model estimates are the average of impulse responses across countries.

Figure 1.13. The results are again very similar to the baseline scenario, with actually a stronger growth in credit when we don't have the financial accelerator in place. Moreover, the increase on investment is also stronger but less persistence. Thus, we can also conclude that, on top of the minor role of balance sheet mismatches, the whole banking sector is not important quantitatively for the transmission of commodity price shocks in the setup of this paper.

Country interest rate and working capital channels. Finally, I evaluate if the country interest and working capital channels can explain the different effects in emerging and advanced economies. To do that, I calibrate the firms' working capital parameters and country interest rate process for each emerging country using the average obtained in the advanced countries and I keep all the other estimated parameters equal to the baseline estimation. The results can be see in Figure 1.14. It shows that the bulk of the difference in impulse responses to commodity price shocks is explained by the interaction between the working capital and the interest rate channel.

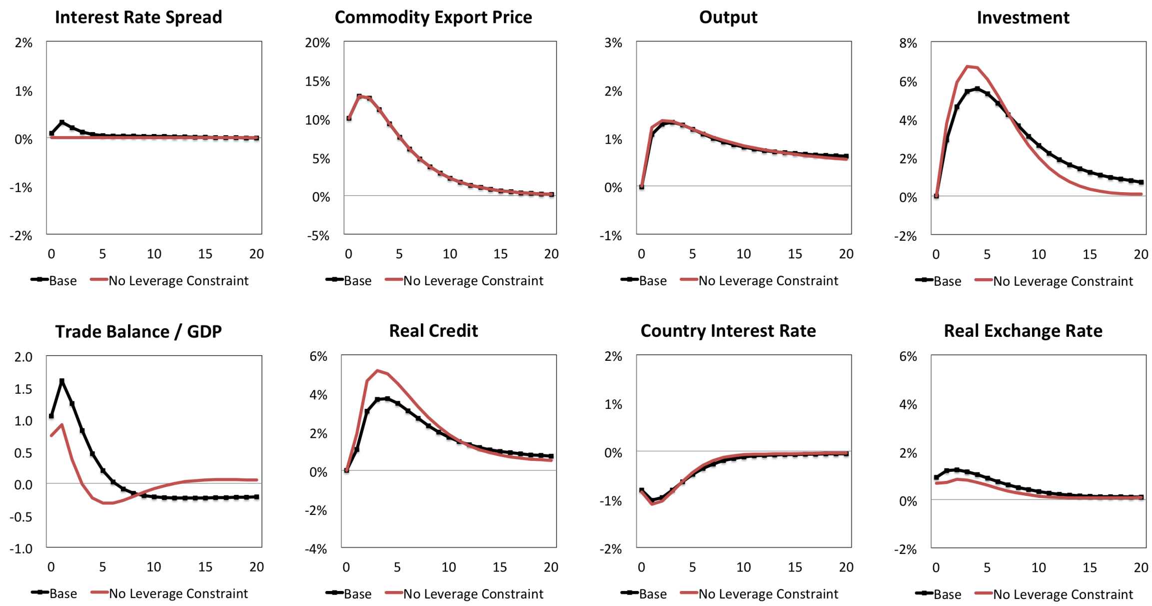

Figure 1.13: Impulse response to a 10% commodity export price shock - No Leverage Constraint.

Note: Marked black (solid red) lines show point estimates of impulse responses for emerging economies for the model in the baseline (alternative) scenario. Model estimates are the average of impulse responses across countries.

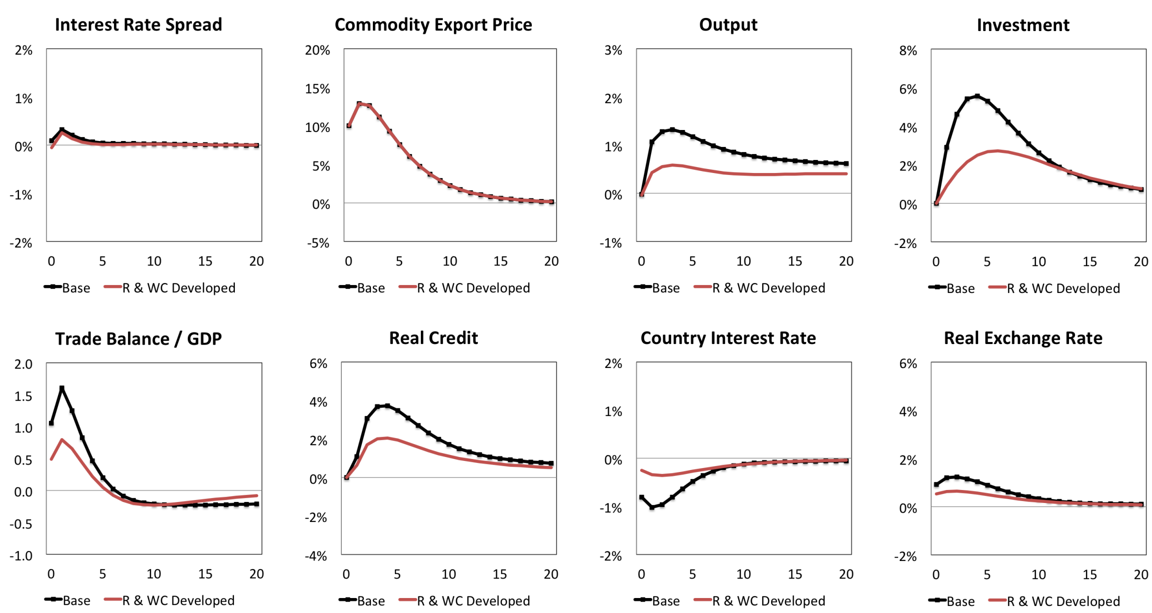

Figure 1.14: Impulse response to a 10% commodity export price shock - Working Capital Constraint parameters and R^* process for Advanced Economies.

Note: Marked black (solid red) lines show point estimates of impulse responses for emerging economies for the model in the baseline (alternative) scenario. Model estimates are the average of impulse responses across countries.

It is clear from the results that the most relevant channels for the transmission of commodity price shocks are the interest rate and working capital channels. Moreover, turning off the balance sheet mismatch and the financial accelerator channels almost do not change the impulse responses, which leads to the conclusion that although theoretically plausible and heavily explored after the recent financial crisis, these frictions do not have relevant quantitative implications in the environment proposed in this paper. This result is related to the response of interest rate spreads, which are small and temporary. Consequently, most of the effects stem from the country interest rate, which experiences a strong and persistent reduction after a commodity price shock; and from differences in working capital constraints, which are how changes in interest rates are transmitted to the real economy through the wedge that they create in firms' hiring and investment decisions.

1.6 Conclusion and Future Research

This paper uses two different methodologies to evaluate the effects of commodity price shocks on small open commodity exporters. First, I estimate a panel VAR and show that commodity price shocks are important sources of business cycles in small open commodity exporters and their effect on real activity, credit and country interest rate is stronger on emerging than on advanced economies. After that, I propose a theoretical framework to evaluate the contribution of different financial frictions to the amplification of commodity price shocks. The model is a three-sector small open economy model with financial intermediaries to be able to account for the dynamics of small open commodity producers. I estimate the model using Bayesian methods and show that it is able to account for the different behavior of emerging and advanced economies, generating impulse responses that are similar to the ones generated by the panel VAR. Moreover, using the estimated model to evaluate the most important financial friction for the amplification of commodity price shocks, I find that the interaction between their effect on the country interest rate through a lower country risk and the presence of different working capital constraints explains the bulk of the difference in the effects on real activity and credit among emerging and advanced economies. Additionally, the presence of balance sheet mismatches and leverage constraints for foreign borrowing in the banking sector do not play a significant role in the transmission of commodity price shocks to the real economy.

The quantitatively small role of the financial accelerator is coherent with previous works that have evaluated this issue (Kocherlakota (2000) and Cordoba and Ripoll (2004) for example). More recently, Brunnermeier and Sannikov (2014) argued that nonlinearities and asymmetries are crucial to generate quantitatively relevant amplification and thus a full characterization of system dynamics far away from the steady state is needed to get accurate results because in that case prices would move more strongly. However, the rich environment proposed in this paper makes it impracticable to work with higher order approximations if we want to perform Bayesian estimation. On the other hand, other features that might lead to a stronger and more persistent effect on spreads such as shocks to net worth, a maturity mismatch in banks' balance sheets, or a time-varying leverage constraint might also make the financial accelerator more important quantitatively. These are planned for future research.

There are other dimensions in which the model could be extended. First, I do not consider any countercyclical policies that might be implemented by governments. Understanding how different monetary and fiscal policy measures could interact with the channels studied in this work would allow a more complete evaluation of the transmission mechanism of commodity price shocks. Moreover, I would be able to study optimal monetary and fiscal policies in countries where this particular shocks are very important. Second, the fact that the main transmission channel is the effect on the interest rate for foreign borrowing might give additional support to countercyclical capital control policies as the ones advocated recently by the IMF and several authors (see for example Ostry et al. (2011), Costinot, Lorenzoni, and Werning (2014), Schmitt-Grohé and Uribe (2015a) and many others). In fact, Chapter 3 of this dissertation shows that the imposition of countercyclical capital controls in Brazil had real effects, especially in investment, a result in line with my findings. However, a welfare analysis of the effects of capital controls is beyond the scope of this work and would depend also on which sectors are the most affected by these policies and the externalities generated by them. While all these issues would require an even more comprehensive framework, they represent exciting opportunities for future research.

Chapter 2

International Reserves, Credit Constraints, and Systemic Sudden Stops

2.1 Introduction

Although we have seen a remarkable increase in the hoarding of international reserves in emerging markets, this practice has been subject of an intense debate. Some authors argue that countries have over-invested in reserves (Rodrik (2006)) while others see this strong buildup as the optimal response for the possible feedback effects of balance of payments crisis (Mendoza (2006)).

This paper proposes a new motive for international reserves accumulation, namely its role as implicit collateral for external borrowing in a small open economy subject to external financial shocks. Although policy makers and financial market participants have often thought that international reserves can serve as collateral for external borrowing, this role has not been formally evaluated before.[1] I evaluate it by including international reserves as collateral for external borrowing in a small open economy model with credit constraints, similar to those in Mendoza (2002) and Bianchi (2011). In this context, I want to understand whether the role of international reserves as collateral for foreign borrowing can explain their high levels in emerging economies and analyze the behavior of macroeconomic variables in crises in such an environment.

My framework sheds some light on the puzzling fact that emerging markets hold very high levels of international reserves and foreign liabilities simultaneously and these holdings are positively correlated, as we can see in Figure 2.1.[2] In this setting, having these liquid assets as collateral allows agents to borrow more funds than would be possible just by selling the assets because it solves an asymmetric problem about the value of resources available at the time of repayment, especially during periods of global

1. There is also some anecdotal evidence regarding this relation. Financial Times, for example, wrote that "Brazil's booming economy, the fact that the country became a net creditor in international markets supporting the credit-worthiness of the corporate sector and its underdeveloped domestic capital markets lead to an impressive performance in corporate issuance since 2007." (Chart of the week: Brazil corporate debt).

2. The correlation between the two variables is 0.4 in the sample of 33 countries shown in Figure 2.1.

financial distress when there is a strong desire for liquidity by foreign investors.[3] Thus, the government may choose to pay the cost of holding elevated levels of international reserves during normal times to relax the credit constraint when the economy is hit by an external financial shock.[4] This policy action allows consumers to hold much more debt than it would be possible otherwise and softens the drastic impact of these negative exogenous shocks on consumption.

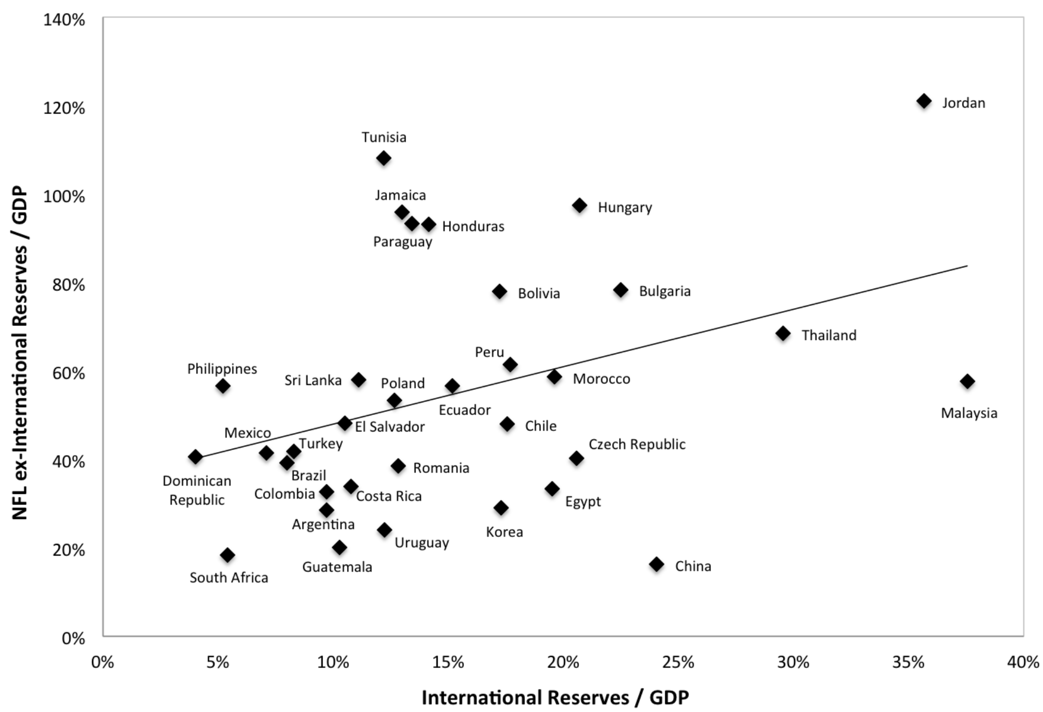

Figure 2.1: Net Foreign Liabilities ex-IR and International Reserves (% of GDP)

Note: The data are the simple average sampled annually from 1991:2011. All variables are expressed in percentage points of GDP.

Source: Authors' computations based on the updated and extended version of the dataset constructed by Lane and Milesi-Ferretti (2007).

I also provide a formal explanation to the recent behavior of international reserves during the Global Financial Crisis. Contrary to the results of almost all models that try to determine the adequate level of international reserves, most countries had a small and

3. Siritto (2016) also has a model where the asset is worth more for banks than its dividend stream as it allows them to invest in risky loans which, on top of paying dividends, resolve the banks' maturity mismatch problem and relax a borrowing constraint.

4. Rodrik (2006) estimates the income loss due to reserve accumulation in developing countries to be close to 1% of GDP.

short-lived international reserves depletion during the GFC, rebuilding their stocks very quickly.[5] Due to this fact, Aizenman and Sun (2012) stated that during the Global Financial Crisis the "fear of losing reserves seems to play a key role in shaping the actual use of international reserves by emerging markets".[6] Although this could lead to a reevaluation of the role of reserves as insurance against Sudden Stops, especially when we have a floating exchange rate regime, the financial resilience of emerging market economies during the Global Financial Crisis strongly suggests that having a high level of reserves can help countries to deal with sharp changes in global financial conditions in a much better way even if they are not heavily used.[7]

This paper is robust to the critique of other authors that challenge the validity of the assumption of the use of international reserves as collateral because they are legally protected against attachment by creditors under different law systems.[8] However, the idea behind the assumption that international reserves serve as an implicit collateral is not based on any contractual arrangement but relies on the fact that there would be strong reputational effects if the government or the private sector defaulted in the presence of international reserves that could be used to comply with these obligations. In fact, Aizenman (2009) and De Gregorio (2013) point out that the credibility of Brazil's, Mexico's and Korea's anti-crisis measures unveiled in the second half of 2008 was reinforced by their massive stock of reserves.

Quantitative analysis show that the model does well in several dimensions. First, I find that we can get international reserves holdings close to the average reserves-to-GDP ratio in Latin American countries and these results are robust to different

5. The only exception as far as I am concerned is the model presented by Alfaro and Kanczuk (2013), where the level of international reserves also remains high during crises. In their framework, international reserves act as a hedge against external shocks as they increase the stabilizing effect of domestic debt.

6. Bussiere et al. (2015) state that "international reserves should be viewed as being akin to 'nuclear weapon' having a deterrent effect, rather than to true 'gunpowder', to be used in intervention.". They also conclude that the level of short-term debt is the main determinant of the level of reserves, which supports my conclusions.

7. De Gregorio (2013) also points out the important role played by international reserves in the resilience displayed by emerging markets economies during the Global Financial Crisis.

8. See Panizza, Sturzenegger, and Zettelmeyer (2009).

parametrizations. Thus, when we consider the joint decision by a country to hold foreign debt and international reserves, the government chooses to hold a significant amount of reserves even if we just allow for one-period debt. This result contrasts with those of Alfaro and Kanczuk (2009b) and Bianchi, Hatchondo, and Martinez (2014), who find that the optimal policy when you have only one-period debt is not to hold reserves at all.[9] Moreover, the optimal behavior during crises implies an increase of reserve holdings before a Sudden Stop and a small reduction during it, which is coherent with what was observed in the Global Financial Crisis. Finally, an alternative policy of keeping reserves at a constant level equal to its average value all the time yields very similar result to the optimal policy during sudden stops, highlighting the stabilizing role of reserves even if Central Banks don't use them at all, as noted by De Gregorio (2011).

These results hinge on the following mechanism: when the economy is hit by an external shock, there is a drastic reduction on the amount of output that can be pledged as collateral for external borrowing. On the other hand, as international reserves are very liquid assets, their collateral value is always the same independently of the state of global financial markets. Consequently, the government might want to keep a stock of international reserves in case the country is hit by an external shock to smooth the necessary deleveraging during these periods. The government then faces a trade-off between the benefits of keeping reserves that serve as collateral for foreign borrowing in bad times and the cost of carrying this stock of reserves. Thus, international reserves serve as a credit line that the country can use in periods when its ability to borrow is heavily constrained.

Related Literature. This paper lies at the intersection of different lines of literature. First, it is related to the literature that tries to explain reserve accumulation in emerging markets. Some authors argue that reserve accumulation has a mercantilist motive and is related to competitiveness in international trade. Dooley, Folkerts-Landau, and Garber

9. Bianchi, Hatchondo, and Martinez (2014) find that having long-duration bonds is key to get significant levels of debt and reserves simultaneously.

(2004a) state this motivation specifically for China, where a strategy of export promotion and consequently the desire of a depreciated currency leads to sizable reserve accumulation. Moreover, international reserves could serve as collateral for FDI and all the learning externalities that might come with investment in the tradable sector (Dooley, Folkerts-Landau, and Garber (2004b). To address this issue, Korinek and Servén (2016) build a stylized model that incorporates learning-by-investment externalities and a capital intensive tradable goods sector. They show that in their setup the net welfare effects depend on the balance between the static losses from lower tradable absorption and the dynamic gains from higher growth. However, their calibrated model suggests that the welfare benefits of reserve accumulation are outweighed by its costs for standard parameter values.

Another strand of the literature sees reserve accumulation as a form of precautionary savings. To quantify the level of reserves that can be justified as an insurance against capital flow volatility, Jeanne and Ranciere (2011) present a model of the optimal level of international reserves for small open economies seeking insurance against Sudden Stops in capital flows. They find that plausible calibrations can explain reserves of the order of magnitude observed in many emerging countries but Emerging Asia, where one has to assume a large anticipated output cost of Sudden Stops and a high level of risk aversion to explain their reserves to GDP ratio. However, in their model reserves are insurance contracts which pay off only in a sudden stop while what we see in practice is that international reserves are composed mostly by non-contingent risk free assets. Alfaro and Kanczuk (2009b) study the joint decision of holding sovereign debt and reserves and find that the optimal policy is not to hold reserves at all as they increase the willingness to default of the country, which makes debt more costly. On the other hand, Salomão (2013) shows that their result is not robust to the introduction of asymmetric default costs as in Arellano (2008). In this case, the optimal policy is to accumulate positive levels of debt and reserves in equilibrium. Bianchi, Hatchondo, and Martinez (2014) propose a model where reserves provide insurance against future increases in the borrowing cost when there is the possibility of sovereign default. Thus, depending on the probability of higher borrowing cost in the future, the government may be willing to pay the financial cost of reserve accumulation to avoid the need to rollover debt at a high cost when faced by a Sudden Stop. Finally, extending the precautionary approach, Obstfeld, Shambaugh, and Taylor (2010) build a model based on the idea that reserve accumulation is a tool for managing domestic financial instability and smoothing exchange rate fluctuations. They argue that, in a double drain scenario, domestic capital flight is financed through withdrawals of domestic bank deposits. In their setup, the growth of banking systems and financial markets in emerging markets explains almost all the recent buildup of reserve holdings.[10]

This paper contributes to this literature by showing that introducing international reserves as an implicit collateral for foreign borrowing in a small open economy model subject to exogenous financial shocks leads to optimal levels of reserves and debt to GDP similar to what we observe in Latin America. This result is obtained in an environment where there is only short term debt, contrary to the findings of Alfaro and Kanczuk (2009b) and Bianchi, Hatchondo, and Martinez (2014), who argue that in the presence only of short term debt the optimal holdings of international reserves is zero.

The paper is also related to the literature which focus in the rate of return dominance puzzle, ie, why low-return assets are used in reality given the availability of risk-free assets with higher return. The most prominent strand of this literature is the one who studies the credit card puzzle, ie, why many households have simultaneously significant credit card debit and low return liquid assets. To explain this puzzle, Telyukova (2013) and Telyukova and Wright (2008) present models where individuals anticipate needing some liquidity in situations where credit cards cannot be used. My model provides in the context of a sovereign a similar explanation for holding very liquid assets

10. Levy Yeyati and Sturzenegger (2010) also argue that the path of reserve accumulation suggests that it is better explained by an exchange rate smoothing policy than by a pure precautionary motive.

(international reserves) and debt at the same time.

Layout. The rest of the paper is organized as follows. Section 2.2 illustrates the mechanism behind my results in a simple environment. Section 2.3 builds a quantitative business cycle model including international reserves as collateral for foreign borrowing. Section 2.4 details the calibration and simulation of the model and presents its unconditional moments, the behavior of different variables during crises and analyzes the implications of an alternative policy where we keep international reserves at constant levels for all periods. Section 2.5 evaluates the sensitivity of the results to some specific parameters. Section 2.6 concludes.

2.2 A Simple Model

I present now a simple model to provide some intuition on how the mechanism works. The economy lasts for three periods, receives a deterministic endowment only in the last one and might face an exogenous shock in the intermediate period that limits the amount of borrowing to a multiple of international reserves held by the government, which gives a motive for reserve accumulation. I present the full model in the next section.

2.2.1 Environment

The economy lasts for three periods t = 0,1,2. There is only one good and a representative agent receives a deterministic sequence of endowments given by $y_0 = y_1 = 0$ and $y_2 > 0$. The household only values consumption in periods 1 and 2 and maximizes the discounted expected future flow of utility using a subjective discount factor $\beta \in (0, 1)$. Households can borrow from abroad subject to an interest rate r exogenously determined. I assume for simplicity that $\beta(1 + r) = 1$ and the utility function is given by $u(c) = ln(c)$.

The economy is subject to a "sudden stop shock" in period 1. If the sudden stop shock materializes, borrowing in period 1 is limited to a multiple κ^{ir} of international reserves held by the government. A sudden stop occurs with probability $\pi\epsilon[0,1]$.

At $t = 0$, the government can accumulate reserves through lump-sum taxation on households. The only reason to accumulate international reserves is to use them as collateral for external borrowing if the economy is faced by the sudden-stop shock in period 1.

Let b_{t+1} denote the bond purchased by agents in period t. A negative value means an issuance of bonds by households. The budget constraints for each period for the whole economy are given by:

$$IR_1 \leq -b_1$$

$$c_1 \leq (1+r)b_1 - b_2 + IR_1$$

$$b_2(s_0) \geq -\kappa^{ir} IR_1$$

$$b_2(s_1) \geq -\frac{c_2 - y_2}{1+r}$$

$$c_2 \leq y_2 + b_2(1+r)$$

where s_0 denotes a sudden stop state and s_1 denotes a normal state. Figure 2.2 shows the timing of decisions and correspondent utilities at each period for the simple model when all budget constraints are satisfied with equality.

2.2.2 Analytical Results

A social planner maximizes the expected utility choosing the optimal level of reserves and consumption at $t = \{1, 2\}$. If the economy is not subject to a sudden stop shock, the solution is trivially $c_1^* = c_2^* = y_2/(2+r)$. However, a sudden stop may prevent agents from borrowing in period 1 if there aren't any international reserves in place.
Substituting the budget constraints for different states into the utility function, the

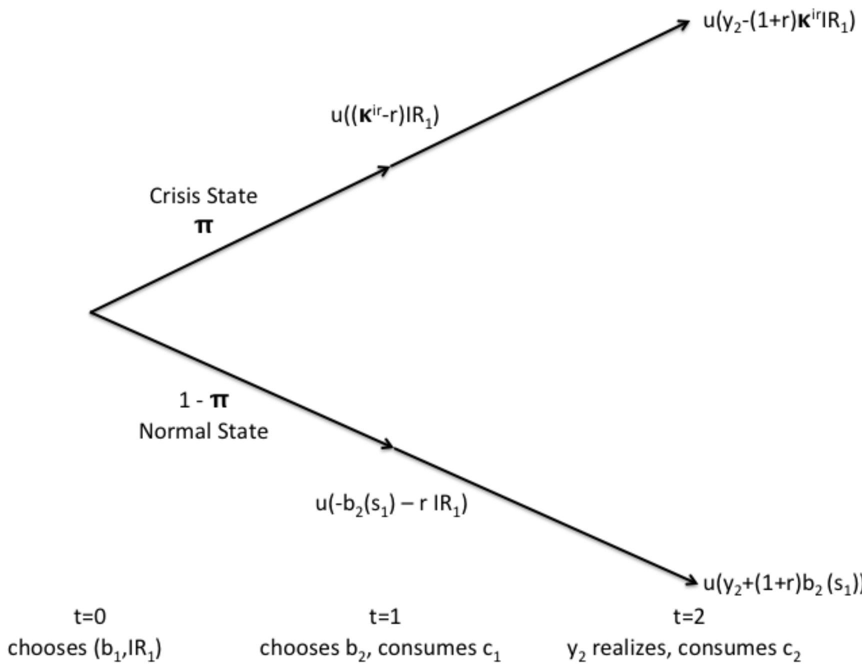

Figure 2.2: Timing of Decisions and Utilities - Simple Model

problem for the social planner is given by:

$$\max_{IR_1, b_2(s_1)} \pi\{ln[(\kappa^{ir} - r)IR_1] + \beta ln[y_2 - (1+r)\kappa^{ir} IR_1]\} + (1-\pi)\{ln[-b_2(s_1) - rIR_1] + \beta ln[y_2 + b_2(s_1)(1+r)]\}$$

It is clear from the social planner's problem the costs and benefits of holding reserves: on the one hand, there is a cost of carrying reserves from period 0 to 1, which is given by rIR_1 as the agents have to issue bonds to finance the acquisition of international reserves; on the other hand, if the economy is hit by a sudden stop shock, it allows to increase consumption by $\kappa^{ir} IR_1$ in period 1.

Taking first order conditions, the optimal level of reserves holdings is given implicitly by the following expression:

$$\frac{y_2 - (2+r)k^{ir} IR_1}{y_2 - \kappa^{ir} IR_1(1+r)} - \left(\frac{1-\pi}{\pi}\right) \frac{r(2+r)IR_1}{y_2 - r(1+r)IR_1} = 0$$

which has as solution a linear function in y_2:

$$IR_1 = K(r, \pi, \kappa^{ir})y_2$$

where the constants are given by[11]

$$K(r, \pi, \kappa^{ir}) = \frac{K_2 - K_3}{K_1}$$

$$K_1 = 2r(2+r)(1+r)\kappa^{ir}$$

$$K_2 = (2+r)\kappa^{ir}\pi + r(2+r-\pi)$$

$$K_3 = \sqrt{K_2^2 - 2\pi K_1}$$

and has the following properties

1. IR_1 is strictly increasing in π
2. IR_1 is strictly decreasing in r
3. IR_1 is strictly decreasing in κ^{ir}
4. IR_1 is strictly increasing in y_2 as $K\epsilon(0, 1/2]$

Consequently, if the probability of a sudden stop is high, the optimal level of reserves is also higher as an insurance against it. Moreover, if the opportunity cost of holding reserves is high, the optimal reserves holdings are lower. Additionally, if the collateral value of reserves is high, the optimal holdings are also lower as we need less reserves to get the same foreign borrowing level. Finally, if output is higher in the future, it pays off to carry more reserves as an insurance against the bad state.

In the next section, I present a detailed model that will allow me to evaluate the quantitative implications of the role of reserves as collateral to account for the level of reserve holdings in emerging markets and their behavior during crises.

11. $K(r, \pi, \kappa^{ir}) = (K_2 + K_3)/K_1$ violates the feasibility conditions in the economy as it greater than 1 so we have as unique solution $K(r, \pi, \kappa^{ir}) = (K_2 - K_3)/K_1$.

2.3 A QUANTITATIVE BUSINESS CYCLE MODEL WITH INTERNATIONAL RESERVES AS COLLATERAL

This section presents a small open endowment economy where foreign creditors constraint the amount that they lend to a share of tradable output and a multiple of the international reserves held by the government. In this setting, the main purpose of reserves is to facilitate external borrowing when the economy is hit by an exogenous shock that drastically reduces the amount of output that can be pledged as collateral. This way, the government faces a trade-off between the benefits of keeping reserves that serve as collateral for foreign borrowing in bad times and the cost of carrying this stock of reserves, as we saw in the simple model of Section 2.2. After detailing the model, I present both the competitive equilibrium and the socially optimal one.

2.3.1 Theoretical Framework

I model a small open endowment economy where the preferences of the representative consumer are represented by a time-separable utility function:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(c_t) \right\} \tag{2.1}$$

where $\beta \in (0,1)$ is a subjective discount factor.

The consumption basket is a CES aggregator with elasticity of substitution η between tradable c_t^T and nontradable goods c_t^N:

$$c_t \equiv A(c_t^T, c_t^N) = [\omega (c_t^T)^{-\eta} + (1-\omega)(c_t^N)^{-\eta}]^{-\frac{1}{\eta}}$$

Every period, consumers receive an endowment of traded y_t^T and nontraded y_t^N goods. Markets of contingent claims are incomplete so consumers can only trade one-period bonds on international capital markets.[12] The face value of these bonds specifies the amount that will be paid in the next period, b_{t+1}. I normalize the price of tradables to 1 and define the relative price of nontradables as p^N. I also assume that the Government accumulates reserves through lump-sum taxation τ_t. The households' budget constraint is consequently:

$$c_t^T + p_t^N c_t^N + b_{t+1} + \tau_{t+1} = y_t^T + p_t^N y_t^N + (1+r)b_t \tag{2.2}$$

and as the Government only taxes agents to accumulate international reserves and runs a balanced budget, its budget constraint is given by

$$\tau_{t+1} = \Delta IR_{t+1} \tag{2.3}$$

The central assumption of the model is that creditors constraint the amount that they lend to a fraction κ_t^T of tradable income plus κ^{ir} times the total stock of international reserves:

$$b_{t+1} \geq -[\kappa_t^T y_t^T + \kappa^{ir} IR_t] \tag{2.4}$$

where κ_t^T is an exogenous parameter that represents the state of international financial markets. I assume that κ_t^T can take two different values, $\kappa^{T,H}$, which is related to normal times, and $\kappa^{T,L}$, which is related to disruptions in financial markets, capturing the feature that extreme capital flows episodes are significantly related to global risk, as we can see for example in Calvo (2005) and Forbes and Warnock (2012).[13] The level of international

12. I limit my analysis to short-term debt instead of long term debt as in Bianchi, Hatchondo, and Martinez (2014) based on the results of Broner, Lorenzoni, and Schmukler (2013). They argue that the predominance of short-term debt in developing countries happens because investors charge a higher risk-premium on long-term bonds and this relative cost increases even more on crisis, making it much cheaper for emerging markets to borrow short-term. Alfaro and Kanczuk (2009a) also show that the optimal structure for Emerging Markets is usually to have only short-term debt, although in their model this arises from the fact that the costs of defaulting increase more than its benefits when maturity increases.

13. Eggertsson and Krugman (2012) also have a model where views about safe levels of leverage change abruptly over time, an event they call a Wile E. Coyote moment based on the famous Road Runner cartoon.

reserves is taken as given from the perspective of the households. We can think as this borrowing limit being the result of an incentive constraint coming from information asymmetries between borrowers and lenders and underdeveloped financial markets, which leads to limited enforcement. For simplicity, I assume it as exogenously given.

The possibility of using international reserves as collateral has been challenged by different authors such as Alfaro and Kanczuk (2009b). However, although central bank assets are legally protected against attachment by creditors under the Foreign Sovereign Immunities Act of 1976 of the USA and comparable laws, the argument for the inclusion of international reserves as collateral relies on the reputational costs of a default in external borrowing by the government or the private sector in the presence of international reserves that could be used to fulfill these obligations. In practice, we usually see a positive correlation between the stocks of international reserves and short-term foreign debt. Dominguez, Hashimoto, and Ito (2012), for example, find that countries that accumulated larger stocks of reserves prior to the Global Financial Crisis also had higher short-term debt to GDP ratios. I will show later that this is also the case for the crises episodes that I study in this paper.

2.3.2 Competitive Equilibrium

Households choose $\{c_t^T, c_t^N, b_{t+1}\}_{t\geq 0}$ to maximize expected utility (1) subject to the budget constraint (2) and the borrowing limit (4), taking b_0, p_t^N, τ_{t+1} and IR_t as given. Defining $G(c_t^T, c_t^N) \equiv U'(c_t)A_1(c_t^T, c_t^N)$, the first-order conditions are:

$$G(c_t^T, c_t^N) = \lambda_t \tag{2.5}$$

$$p_t^N = \left(\frac{1-\omega}{\omega}\right)\left(\frac{c_t^T}{c_t^N}\right)^{\eta+1} \tag{2.6}$$

$$\lambda_t = \beta(1+r)E_t\lambda_{t+1} + \mu_t \tag{2.7}$$

$$\mu_t \geq 0, \quad \mu_t[b_{t+1} + \kappa_t^T y_t^T + \kappa^{ir} IR_t] = 0 \tag{2.8}$$

Market clearing conditions are given by

$$c_t^N = y_t^N \tag{2.9}$$

$$\tau_{t+1} = \Delta IR_{t+1} \tag{2.10}$$

Definition 1 (Decentralized Competitive Equilibrium): A competitive equilibrium is a set of processess $\{c_t^T, b_{t+1}, \mu_t\}_{t\geq 0}$ satisfying:

$$G(c_t^T, y_t^N) = \beta(1+r)E_t G(c_{t+1}^T, y_{t+1}^N) + \mu_t \tag{2.11}$$

$$b_{t+1} = y_t^T - c_t^T + (1+r)b_t - \Delta IR_{t+1} \tag{2.12}$$

$$b_{t+1} \geq -\left[\kappa_t^T y_t^T + \kappa^{ir} IR_t\right] \tag{2.13}$$

$$\mu_t \geq 0, \quad \mu_t \left[b_{t+1} + \kappa_t^T y_t^T + \kappa^{ir} IR_t\right] = 0 \tag{2.14}$$

given processes $\{y_t^T, y_t^N, IR_t\}_{t\geq 0}$ and the initial condition b_{-1}.

2.3.3 Socially Optimal Equilibrium

So far I just stated that households solve their optimization problem taking the stock of international reserves as exogenously given. To determine the optimal amount of international reserves at each period t, I write the optimization problem in recursive form and solve the social planner's problem. The social planner's problem consists in choosing $\{IR_{t+1}, b_{t+1}, c_t^T\}$ given $\{IR_t, b_t, y_t^T, y_t^N\}$ to maximize expected utility subject to the budget constraint and the collateral constraint:

$$V(IR, b, \mathbf{y}) = \max_{IR', b', c^T} u(c(c^T, y^N)) + \beta E_{y'|y} V(IR', b', \mathbf{y'})$$

subject to

$$c^T + b' + IR' = y^T + b(1+r) + IR$$

$$b' \geq -(\kappa^T y_t^T + \kappa^{ir} IR)$$

The first order conditions associated with this problem are now:

$$G(c_t^T, y_t^N) = \beta(1+r)E_t G(c_{t+1}^T, y_{t+1}^N) + \mu_t \tag{2.15}$$

$$G(c_t^T, y_t^N) = \beta E_t\{G(c_{t+1}^T, y_{t+1}^N) + \mu_{t+1}\kappa_{ir}\} \tag{2.16}$$

$$\mu_t \geq 0, \quad \mu_t \left[b_{t+1} + \kappa_t^T y_t^T + \kappa^{ir} IR_t\right] = 0 \tag{2.17}$$

Notice that the competitive equilibrium and the socially optimal one have the same Euler Equation and differ only because now the planner also chooses optimally the level of international reserves through equation (2.16). Thus, to implement the Social Planner's equilibrium as a competitive equilibrium the planner chooses the optimal IR_{t+1} given current conditions and then finance it through lump-sum taxation of the households making $\tau_{t+1} = \Delta IR_{t+1}$.

2.4 Quantitative Analysis

This section calibrates and simulates the model, showing that it can yield international reserves to GDP ratios close to what we see in practice. I also get that the cyclical behavior of the current account and external debt is very close to what we observe in practice, while that of international reserves is somewhat different. Moreover, the optimal policy leads to reserve accumulation before a Sudden Stop and a small depletion during it, which is close to what we see in the annual data. Finally, I evaluate the behavior of the model under a simpler passive rule for reserve accumulation where the Central Bank keeps international reserves levels constant all the time and find that the behavior of consumption in crises under the passive rule is very similar to what we is obtained under the optimal policy.

2.4.1 Long-Run Business Cycle Moments in the Data

I begin the analysis by looking at the main statistics regarding international reserves, net foreign liabilities ex-international reserves and current account balance for the larger Latin American Countries, shown in Table 2.1. As we can see, the average ratio of international reserves to GDP is close to 10% while that of net foreign liabilities ex-international reserves is around 37%. Moreover, international reserves are acyclical while the other variables are countercyclical.

	2012	Average	Std	Autocorr.	Correl(y)
International Reserves	12.2%	9.7%	3.0%	0.39	0.02
Net Foreign Liabilities ex-IR	31.8%	36.7%	13.5%	0.66	-0.40
Current Account	-2.0%	-1.4%	2.6%	0.68	-0.38

Note: The data are the simple average of the indicators for the five main Latin American countries (Argentina, Brazil, Chile, Colombia and Mexico). To calculate the standard deviations and correlations, I detrend the log of Real GDP, International Reserves to GDP and Net Foreign Liabilities ex-International Reserves to GDP ratios taking out a linear and a quadratic trend. Current Account to GDP ratio is not detrended as it is stationary. The data are from the World Development Indicators database from the World Bank and the updated and extended version of the dataset constructed by Lane and Milesi-Ferretti (2007). The data are sampled annually from 1991:2012.

Table 2.1: Summary statistics - Latin America (% of GDP)

2.4.2 Sudden Stops Episodes

Following Calvo, Izquierdo, and Mejia (2008) and Alberola, Erce, and Serena (2016), I focus on Systemic Sudden Stops, ie, episodes triggered by an exogenous financial shock.[14] I use the JP Morgan EMBI Global Index to identify periods of global financial stress in Emerging Markets. These periods are defined as quarters where there is a spike

14. Calvo, Izquierdo, and Mejia (2008) argue that focusing on Systemic Sudden Stops is desirable because they exclude idiosyncratic crises that can result from factors such as political turmoil and disasters. These idiosyncratic crises have several different features compared to the ones I isolate here.

in the EMBI Global spread with respect to its 2 year moving average. This way, I have four global financial stress events: 1995, 1999, 2002 and 2009, which are the well known Tequila, Russian-Asian, Argentinean and Global Financial Crises. Using these global crises dates we can then identify the Sudden Stops episodes, which are those dates where the country experiences a one standard deviation reversal in the current account conditional on being in a global crisis year. The methodology yields eight Sudden Stops episodes for the five Latin American countries studied in this paper. The list of episodes can be seen in Table 2.2.

Country	Years of Sudden Stops
Argentina	1995, 2002
Brazil	2002
Chile	1999, 2009
Colombia	1999
Mexico	1995, 2009

Table 2.2: Sudden Stops Episodes

Figure 2.3 shows the average behavior of the ratio of current account, international reserves and net foreign liabilities ex-international reserves to GDP in crises. The behavior of this variables is close to what was obtained in previous works by Eichengreen, Gupta, and Mody (2008) and Jeanne (2007). Both international reserves and net foreign liabilities ex-international reserves to GDP ratios increase in the onset of a Sudden Stop episode and decrease after that. The real exchange rate appreciates before the Sudden Stop, suffers a strong depreciation during it and stays at this more depreciated value after that.

2.4.3 Functional Forms and Calibration

The utility function has a constant relative risk aversion (CRRA), ie:

$$U(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma}$$

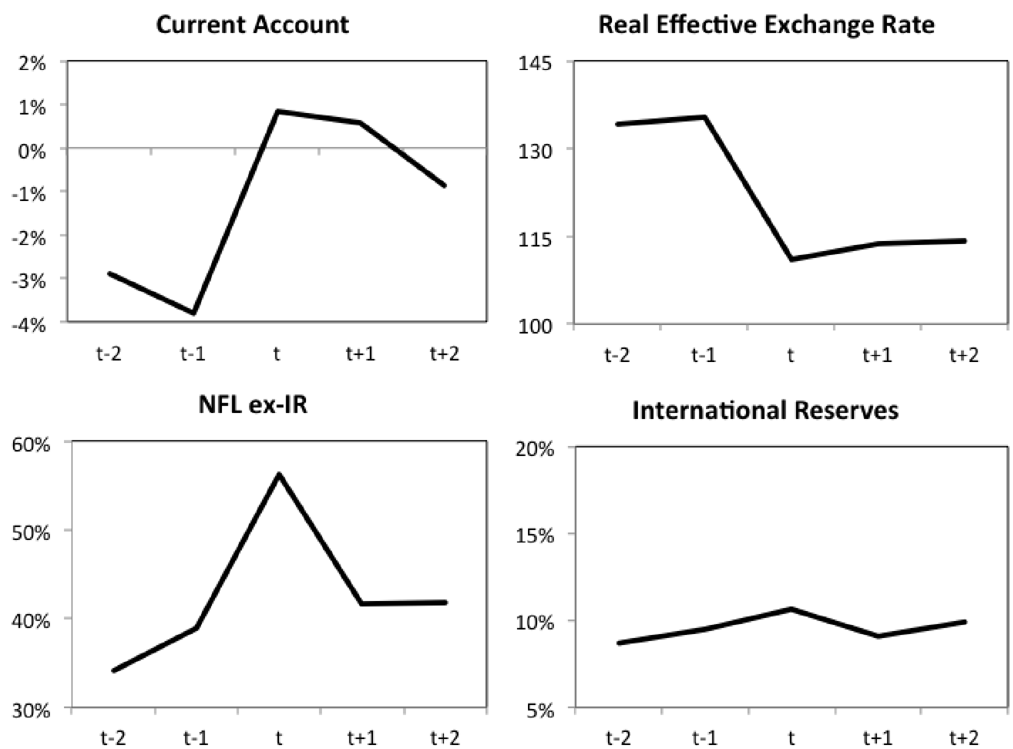

Figure 2.3: Macro Dynamics around Sudden Stops Events

Note: The five year window is centered around a Sudden Stop occurring at time t. The list of countries and Sudden Stops is given in Table 2.2. All variables are expressed in percentage points of GDP except for the Real Exchange Rate.

Source: Authors' computations based on World Bank World Development Indicators (WDI) database.

The endowment process follows a VAR(1):

$$log(\mathbf{y_t}) = \boldsymbol{\rho} log(\mathbf{y_{t-1}}) + \boldsymbol{\epsilon}_t$$

with $|\boldsymbol{\rho}| < 1$ and $\epsilon_t \sim N(0, V)$. I use an average of the process estimated for Argentina, Brazil, Chile, Colombia and Mexico, which yields as $\boldsymbol{\rho}$ and $\mathbf{V}$:

$$\rho = \begin{bmatrix} 0.920 & -0.314 \\ 0.277 & 0.573 \end{bmatrix}$$

$$V = \begin{bmatrix} 0.00248 & 0.00142 \\ 0.00142 & 0.00143 \end{bmatrix}$$

I discretize the process into a first-order Markov process with 4 grid points for each shock using Terry and Knotek (2011) methods', which allows for arbitrary error covariance structures.[15]

κ_t^T can take two values, $\kappa^{T,H}$, which is related to normal times, and $\kappa^{T,L}$, which is related to disruptions in international financial markets. The probability of entering a period of disruptions in international financial markets is given by π while the probability of going back to normal times by ψ.

All the benchmark parameter values can be seen in Table 2.3. A period in the model refers to a year.

Parameter	Value	Source/target
Interest rate	r = 0.04	Standard value
Risk aversion	$\sigma = 2$	Standard value
Atemporal elasticity of substitution	$1/(1+\eta) = 0.8$	Conservative value
Weight on tradables in CES	$\omega = 0.23$	Share of tradable output = 23%
Discount factor	$\beta = 0.93$	Average NFL ex IR-GDP ratio = 36.7%
Probability of entering financial distress	$\pi = 0.2$	CA reversal = 2.9%
Probability of going back to normal times	$\psi = 0.4$	CA recovery = 0.9%
y^T credit coefficient in financial distress	$\kappa^{T,L} = 0.7$	CA standard deviation = 2.6%
IR credit coefficient	$\kappa^{ir} = 2.06$	Frequency of Sudden Stops = 8.0%

Table 2.3: Calibrated Parameter Values

The interest rate r is set to 4% and the coefficient of risk aversion is set to 2, which are standard values in quantitative business cycles analysis for emerging markets. The range of estimates for the atemporal elasticity of substitution $1/(1+\eta)$ is between 0.40 and 0.83, as we can see in Mendoza (2005), so I use 0.8 as a conservative value. The parameter ω defines the share of tradable in the CES aggregator and is defined such that we have 23% share of tradable production, which is the average for the Latin American Countries in my sample.

The subjective discount factor β is set to match the average net foreign liabilities

15. I would like to thank Ed Knotek for providing the code to implement this method.

ex-international reserves to GDP ratio for LAC, which is 36.7% for the period 1991-2012. This criteria yields a beta of 0.93, which is reasonable for annual frequency.

I calibrate $\kappa^{T,H}$ such that the collateral constraint is never binding in normal times.[16] The parameters concerning the behavior of international financial markets disruptions are $\kappa^{T,L}$, the credit coefficient for tradable output in financial distress periods, π, the probability of entering a financial distress period, and ψ, the probability of going back to normal times. They are set to get a current account standard deviation around 2.6%, a current account reversal of close to 2.9% of GDP in the year of a Sudden Stop (compared to average of the previous 3 years) and a posterior reduction in the current account result of 0.9% (compared to the average of the 3 years after the sudden stop), which were obtained from the data analysis shown before. This yields $\kappa^{T,L}$ equal to 0.7, π equal to 0.2 and ψ equal to 0.4. The parameters values obtained for π and ψ are consistent with what is observed in the sample, as we have four international crises in 22 years and they usually last for two years.

Finally, I obtain κ^{ir} by matching the frequency of Sudden Stops for my sample of countries. I obtain κ^{ir} equal to 2.06, which seems reasonable because, as noted by Siritto (2016), the collateral solves an asymmetric information problem about the resources available to the borrower at the time of repayment, creating incentives to tell the truth and allowing agents to borrow more funds than by just selling the assets.[17] I will show later that choosing a wide range of values for κ^{ir} leads to average levels of international reserves close to the baseline scenario if we adjust the subjective discount factor β accordingly to get always the same average net foreign liabilities ex-international reserves, changing mainly the frequency of sudden stops.

16. As $\kappa^{T,H}$ is very high, the lower bound of bond holdings becomes $b_{min} > -\frac{y^T_{min}}{r}$, which is the largest debt that the country can repay.

17. García-Schmidt (2015) include asymmetric information in a model of sovereign borrowing with default and finds that it improves a lot the fit for debt and spreads, which indicates that this is an important feature of emerging markets debt markets.

2.4.4 Borrowing and International Reserves Decisions

Figure 2.4 shows the bond decision rules for both $\kappa^{T,H}$, which I call normal period, and $\kappa^{T,L}$, which I call crisis period. Since the average value of tradable output is equal to 1, we can interpret the results as ratios of the average level of tradable output. As we can see, for the same level of current bond holdings, agents decide to have more debt in t+1 the lower is the tradable output during periods when the collateral constraint is not binding. However, when it is binding agents are restricted to a level of debt around 1.5 times tradable output.

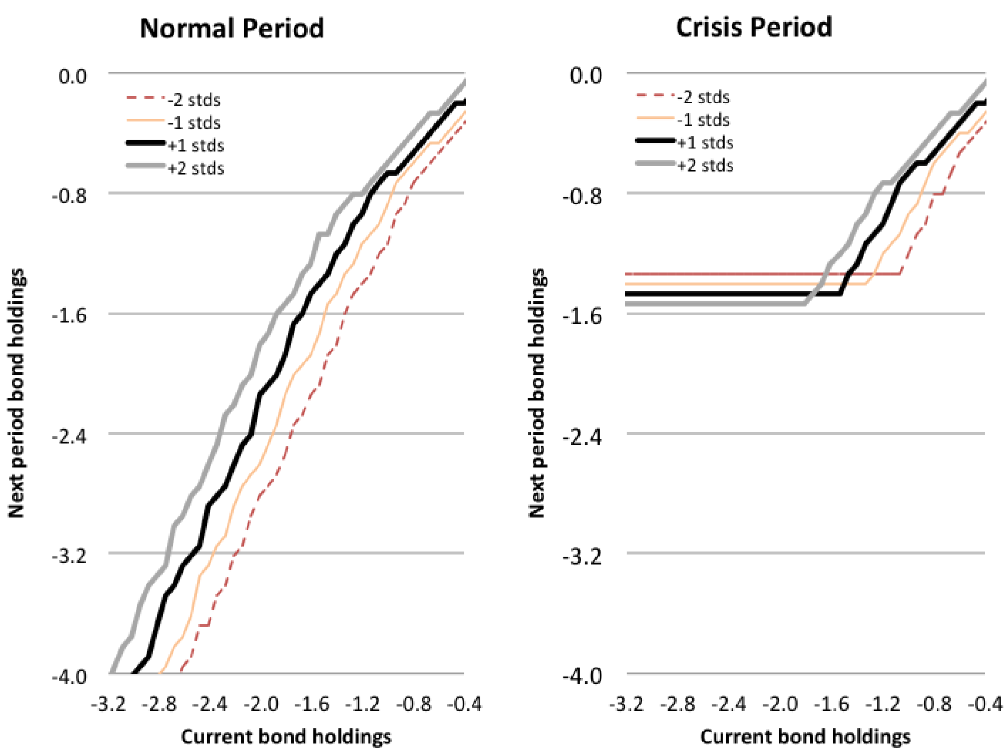

Figure 2.4: Bond Policy Functions

Note: The bond policy functions are calculated for $IR_t = 0.35$, which is the average stock of international reserves in tradable units.

Figure 2.5 shows the international reserves decision rules again for both normal and crisis periods. As we can see, the decision of international reserves holdings depends crucially on whether we are in normal or crisis times. In normal times, the higher the current debt, the more international reserves are accumulated as we are in a more dangerous zone, closer to a binding collateral constraint if international finance conditions turn out to be bad in the following period. During crises, there is a tradeoff between reducing international reserves to consume more today and keeping the reserves in case the crises lasts for more periods in the future. Thus, reserves holdings are kept somewhat around the current level when the collateral constraint is binding and debt levels are not too high as an additional insurance if the crisis continues. On the other hand, there is some reduction in international reserves holdings when current debt is really high to compensate for the strong deleveraging necessary in the current period due to the binding constraint.

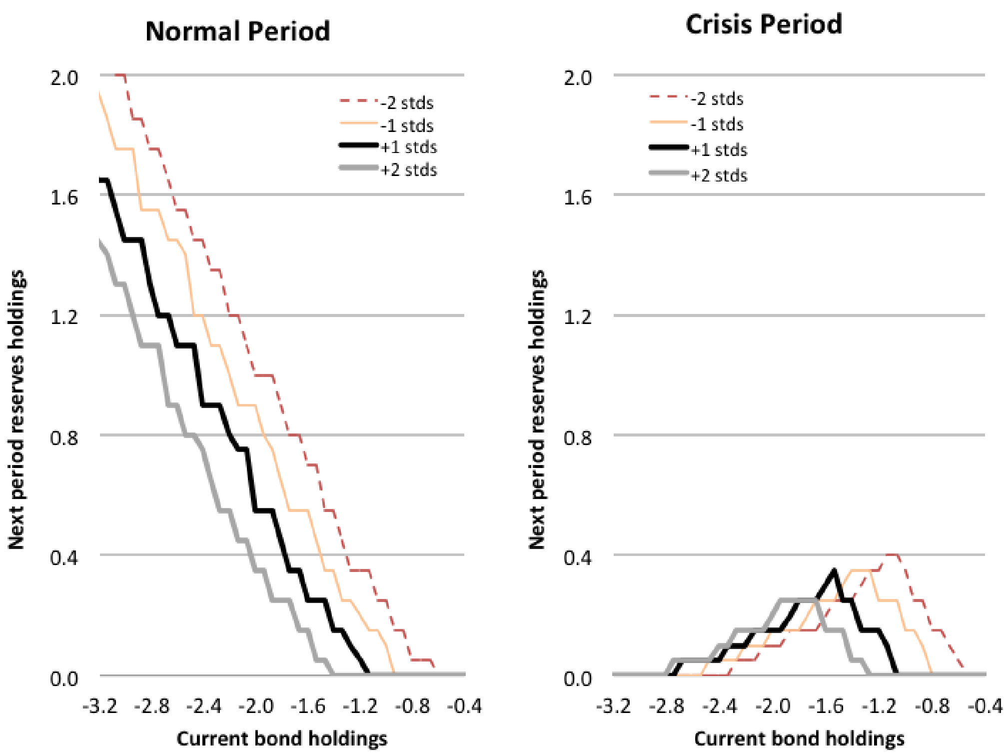

Figure 2.5: International Reserves Policy Functions

Note: The international reserves policy functions are calculated for $IR_t = 0.35$, which is the average stock of international reserves in tradable units.

2.4.5 Long-Run Business Cycle Moments in the Model

In this section, I compare the model unconditional moments to the data. To do that, I conduct a one million periods simulation of the model by drawing a sequence of endowments $\{y_t^T, y_t^N\}$ and tradable output credit constraint coefficient $\{\kappa_t^T\}$ from their distributions and feed them to the policy functions to get the time-series for $\{b_t, c_t^T, c_t^N, IR_t\}$.

Table 2.4 shows that in general I am able to reproduce the main moments in the data. First, I manage to get an average reserves-to-GDP ratio very close to the data. Second, I get countercyclical fluctuations for the current account and net foreign liabilities ex-international reserves and procyclical fluctuations for the real exchange rate, again with results very close to the data.[18] However, I also get countercyclical reserves, which is at odds with what we see in practice, where they are almost acyclical. Finally, the standard deviation of both international reserves and net foreign liabilities ex-international reserves are higher than what we see in the data.

Targeted Moments	Model	Data
Average NFL ex-Reserves-to-GDP	36.6%	36.7%
Frequency of Sudden Stops	8.0%	8.0%
σ(CA/Y)	2.2%	2.6%
Reversal	3.1%	2.9%
Recovery	1.9%	0.9%

Non-Targeted Moments	Model	Data
Average Reserves-to-GDP	8.2%	9.7%
σ(IR/Y)	9.8%	3.0%
σ(NFL ex-IR/Y)	22.3%	13.5%
ρ(y,IR/Y)	-0.50	0.02
ρ(y,-b/Y)	-0.57	-0.40
ρ(y,CA/Y)	-0.36	-0.38
ρ(y,REER)	0.74	0.30

Table 2.4: Long-Run Business Cycle Moments

The high standard deviation of international reserves and net foreign liabilities

18. I use the relative price of nontradables as a measure of the real exchange rate in the model.

ex-international reserves might be explained by the absence of any adjustment costs for agents to adjust their foreign assets positions, as in Schmitt-Grohé and Uribe (2003) for example. The presence of convex portfolio adjustment costs would curb the volatility of both international reserves and net foreign liabilities ex-international reserves, which might lead to numbers closer to the data. It could also solve the issue of the countercyclicality of international reserves, as the government would accumulate more reserves during good times to avoid paying high adjustment costs when it gets closer to a binding collateral constraint. As this was not the main subject of this paper, I decided not to include any adjustment costs.

2.4.6 Sudden Stops Experiments

I now analyze the dynamics of the model during a Sudden Stop and compare it with the data. To construct the implied Sudden Stop events by the model, I do the following steps:

1. Identify crisis events: I define t as a crisis event when we get a current account reversion of 1 standard deviation and a binding collateral constraint;
2. Compute averages of macro quantities of the model centered around these events, were t represents the crisis episode;
3. Compare the outcomes with the average crisis in the data.

As we can see in Figure 2.6, the model can explain the behavior of macroeconomic variables in Sudden Stops with some minor caveats. First, the optimal policy implies that the economy enters the crisis with a higher level of international reserves than what we see in the data. Moreover, international reserves have a small depletion after the onset of a crisis both in the model and in the data. Second, the optimal policy is to keep international reserves somewhat stable after a Sudden Stop and consequently the model cannot explain the rebuilding of international reserves levels after crises that we see in practice. Finally, the behavior of net foreign liabilities ex-international reserves to GDP ratio is close to what we see in the data, although we get a higher and more stable level before the crisis in the model.

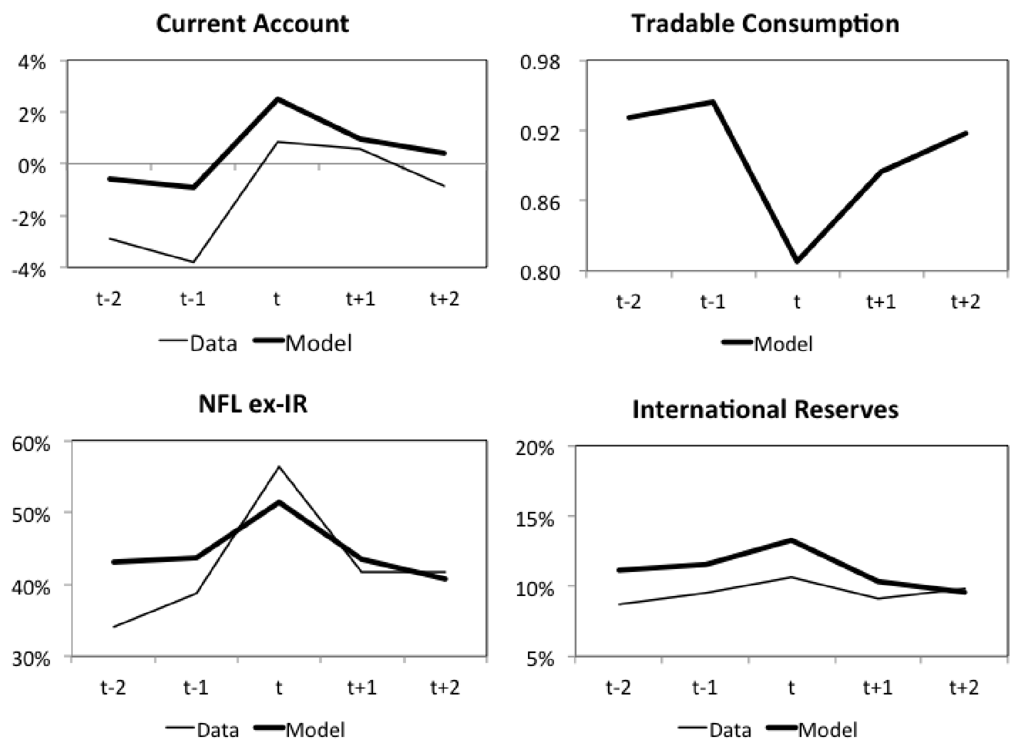

Figure 2.6: Macro Dynamics around Sudden Stops Events

2.4.7 A Simpler Rule - The Passive Central Banker

I now compare the optimal police with a passive Central Banker who just keeps the level of international reserves constant at the average level in tradable goods units in the base scenario for all periods, regardless the state of the economy. The behavior of different variables can be seen in Figure 2.7. The economy with constant international reserves enters the Sudden Stop with a lower level of debt but also has to deleverage as we enter the crises with a lower level of international reserves than in the optimal policy. Moreover, the implied path of tradable consumption is almost the same for both economies. This implies that the welfare benefits of holding reserves during Sudden Stops are quite similar if the Central Bank behaves optimally accumulating more reserves before Sudden Stops and depleting some of them during it or if he just keeps a constant buffer that allows agents to keep their level of external borrowing. This can explain the fear of losing reserves identified by Aizenman and Sun (2012) during the Global Financial Crisis and is coherent with what De Gregorio (2011) pointed out:

> "Countries hoard reserves because they see them as a safety net for periods of financial stress but, in practice, they seldom use them (...) reserves play a stabilizing role simply because they are there and not necessarily to be used."

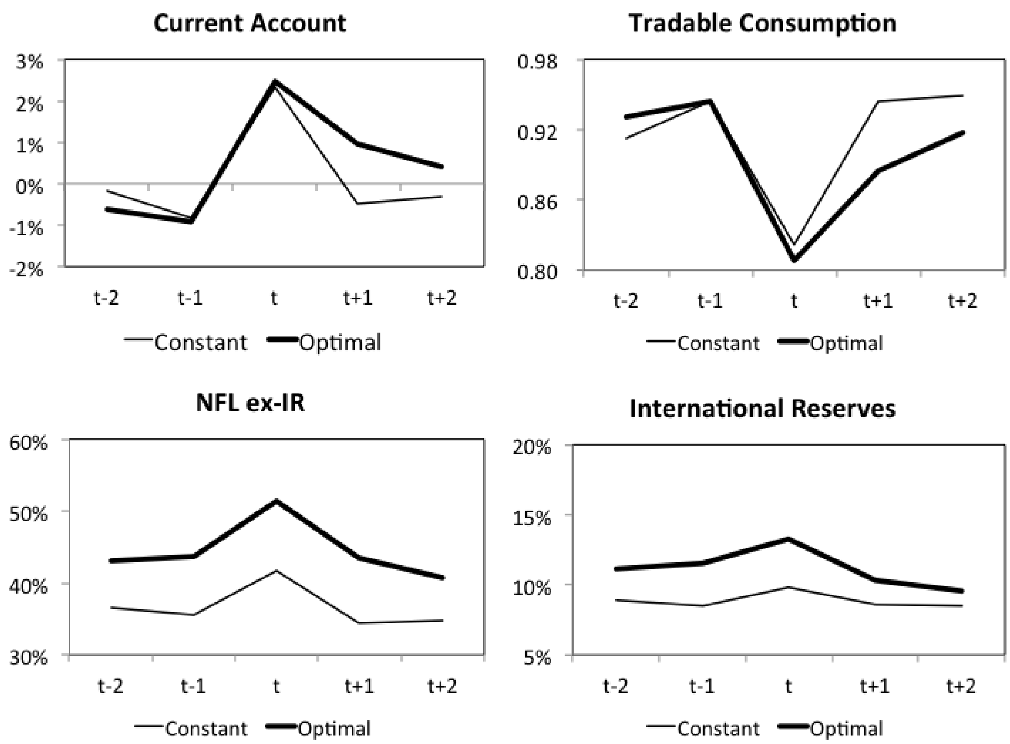

Figure 2.7: Macro Dynamics around Sudden Stops Events - Alternative Policy

However, this passive policy increases the frequency of sudden stops and reduces welfare when we are far away from hitting the collateral constraint, where we would like to reduce the level of international reserves to consume more. Moreover, when we are in states where the collateral constraint might bind in the near future, the optimal policy is to hold a level of international reserves higher than the average to allow for more consumption if the economy is hit by a negative shock in international financial markets.

2.4.8 The High Frequency Behavior of International Reserves

Although we do not see much reserve depletion during crisis on an annual basis, there might be larger IR losses if we look at higher frequencies.[19] Aizenman and Sun (2012), for example, show that most EMs began exhibiting large IR losses during the second half of 2008 and regained most of their losses by the first quarter of 2009. If we look at quarterly data, there is indeed a larger IR depletion also in my sample, as we can see in Figure 2.8, where the average reserves level falls around 15% in US dollars. However, this fall is compensated by the fall in GDP in US dollars due to currency depreciation and recessions experienced by some countries and, consequently, we still get on average an increase in the ratio of international reserves to GDP, coherent with their annual counterpart. Moreover, although it is true that we see some cases of stronger reserve depletion, as in Argentina in the 2002 crisis, these episodes are related to fixed exchange rate regimes, which are not the subject of this paper, where I abstract from studying the effects of different exchange rate policies on reserve accumulation. Finally, the fact that countries reserves holdings start to recover rapidly is another evidence that although they might be used for another purpose in the short term, their role as collateral leads to an urgency of having them back quickly to the previous levels.

2.4.9 Do International Reserves Serve as Collateral?

Until now I have assumed that international reserves are used as collateral, is this really the case? Unfortunately, as the main idea is that reserves serve as an implicit collateral, we cannot infer directly from any database if this is true. However, an implication of my setup is that during periods of international financial stress countries with a higher level of international reserves before these crisis are able to hold more debt

19. I thank Pablo Ottonello for pointing out this fact.

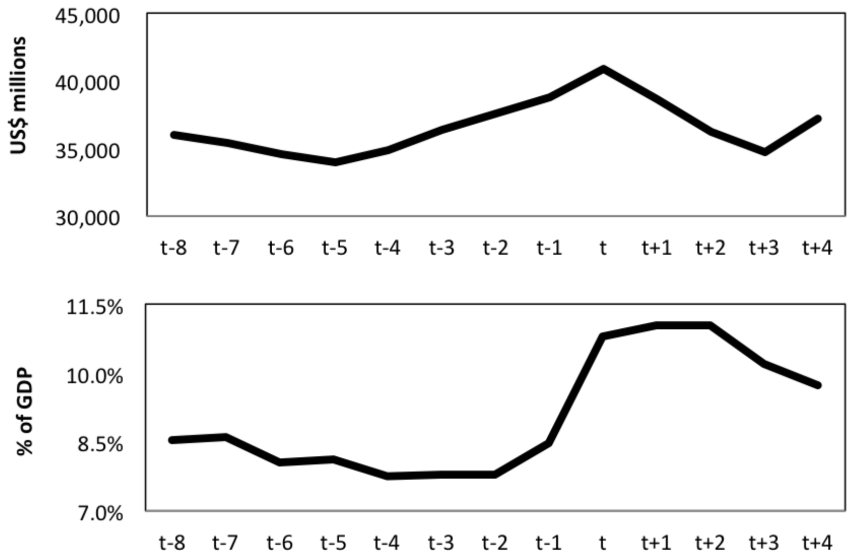

Figure 2.8: International Reserves around Sudden Stops - Quarterly Data

during the crises. I check this implication for several emerging economies, the results are presented in Figure 2.9. As we can see, there is a strong positive correlation between b_{t+1} and IR_t and thus it indicates that foreign lenders do lend more during crisis to countries that have a higher level of international reserves.

2.5 Sensitivity Analysis

In this section, I show the sensitivity of my results to the choice of parameters. First, I evaluate alternative values for the coefficient of international reserves in the collateral constraint. Some people might think that the model can explain any level of international reserves by changing κ_{ir} but I show that if we adjust the subjective discount factor β to get always the same average net foreign liabilities ex-international reserves, the model yields very similar results for any value of this coefficient. After that, I also change the values of the probability of entering a crisis, π, the probability of going back to normal times, ψ, the collateral constraint coefficient during financial distress, $\kappa^{T,L}$, and the atemporal elasticity of substitution, implied by η, adjusting the subjective discount factor β accordingly to get the same average level of net foreign liabilities

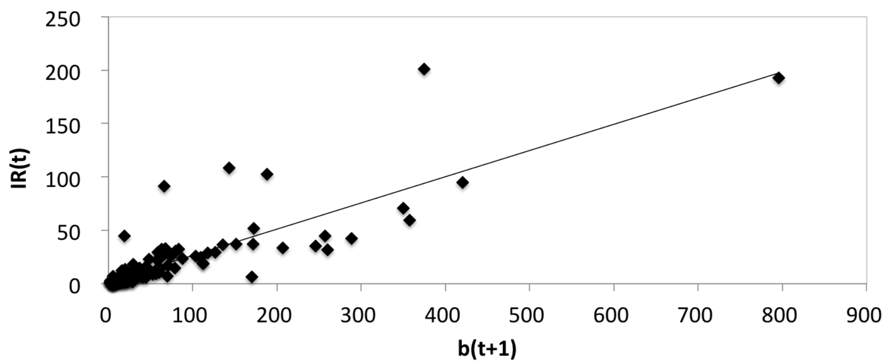

Figure 2.9: Net Foreign Liabilities ex-International Reserves and International Reserves in International Crisis
Note: Each point represents data for a specific country during an international crisis episode. The years of international financial stress are 1995, 1999, 2002 and 2009. The value of international reserves is measured in the beginning of the year of an international financial stress period while that of net foreign liabilities ex-international reserves is measured in the beginning of the following year. The countries included are Argentina, Bolivia, Brazil, Bulgaria, Chile, Colombia, Costa Rica, Czech Republic, Dominican Republic, Ecuador, Egypt, El Salvador, Guatemala, Honduras, Hungary, Jamaica, Jordan, Korea, Malaysia, Mexico, Paraguay, Peru, Philippines, Poland, Romania, South Africa, Sri Lanka, Thailand, Tunisia, Turkey and Uruguay.
Source: Authors' computations based on the updated and extended version of the dataset constructed by Lane and Milesi-Ferretti (2007).

ex-international reserves. Again, the results are not very sensitive to these changes and I get similar results to the baseline scenario.

2.5.1 Can the Model Explain Any Level of International Reserves if I change κ_{ir}?

I now analyze what would happen with the results if I change the value of κ^{ir} and adjust the subjective discount factor β accordingly to get the same average level of net foreign liabilities ex-international reserves. As we can see in Figure 2.10, average reserve holdings are quite similar for all values of κ_{ir}, ranging from 7.4% to 9.4% of GDP. In fact, changing κ_{ir} mainly changes the frequency of sudden stops, which confirms the choice of this variable to calibrate the parameter.[20] This result shows that, contrary to what some people might suspect, the model cannot tautologically generate any level of

20. The frequency of sudden stops goes from 13.6% for κ_{ir} equal to 1.0 to 4.7% for κ_{ir} equal to 2.6.

international reserves just by changing the value of κ_{ir}.

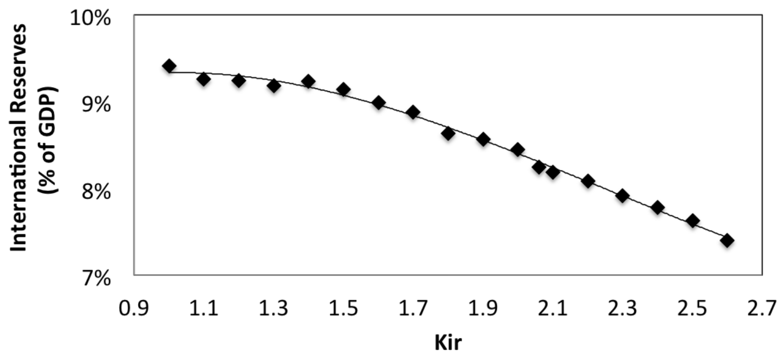

Figure 2.10: International Reserves - Sensitivity to κ_{ir}

2.5.2 Sensitivity to Other Parameters

After analyzing the sensitivity of my results to the choice of κ_{ir}, I do the same for the other parameters of the model. Figures 2.11-2.16 show the model's behavior during crises when I change the collateral constraint coefficient in financial distress, $\kappa^{T,L}$, the probability of going back to normal times, ψ, the probability of entering a crisis, π, and the atemporal elasticity of substitution, implied by η, compared to the baseline scenario. As we can see, the results are very close to what I get in the baseline scenario, which confirms the robustness of the results. However, some differences are worth noting. First, lowering $\kappa^{T,L}$ mainly increases the level of international reserves held during crises to compensate for the lower pledgeability of tradable output as collateral. Second, changing ψ affects mainly the use of reserves during crises. If the probability of exiting the crises is higher, the optimal policy is to use more reserves to reduce consumption less today. Finally, changing π affects the level of reserves and foreign liabilities during crises. A higher probability of entering a crises leads to a higher level of reserves and foreign liabilities in a similar magnitude.

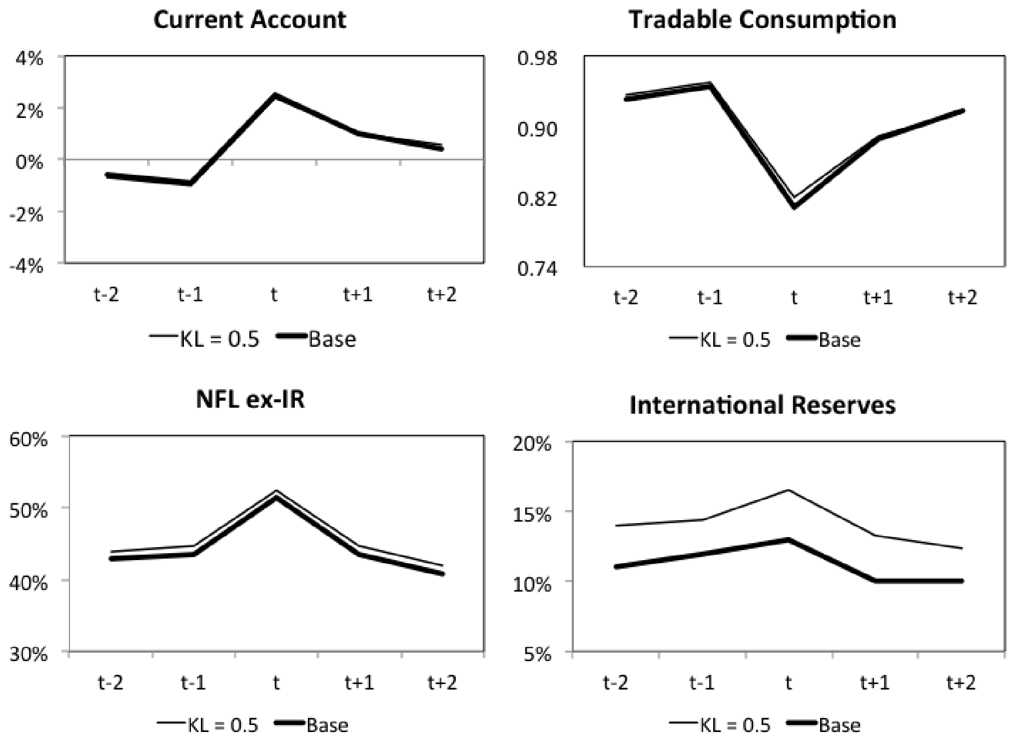

Figure 2.11: Macro Dynamics around Sudden Stops Events - Lower $\kappa^{T,L}$

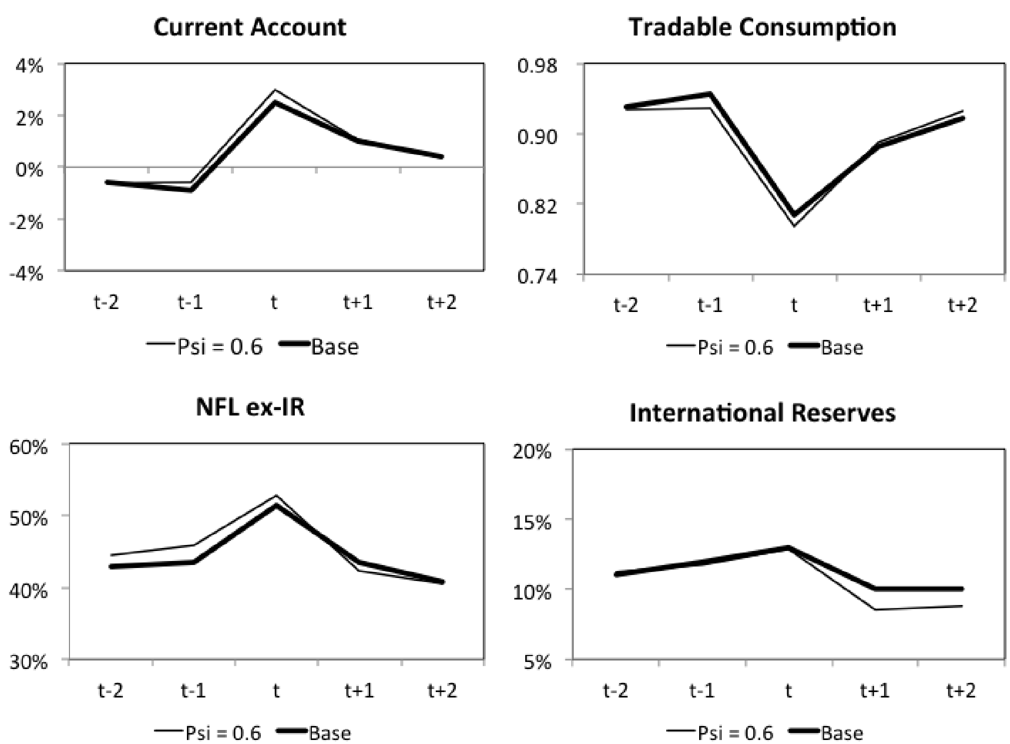

Figure 2.12: Macro Dynamics around Sudden Stops Events - Higher ψ

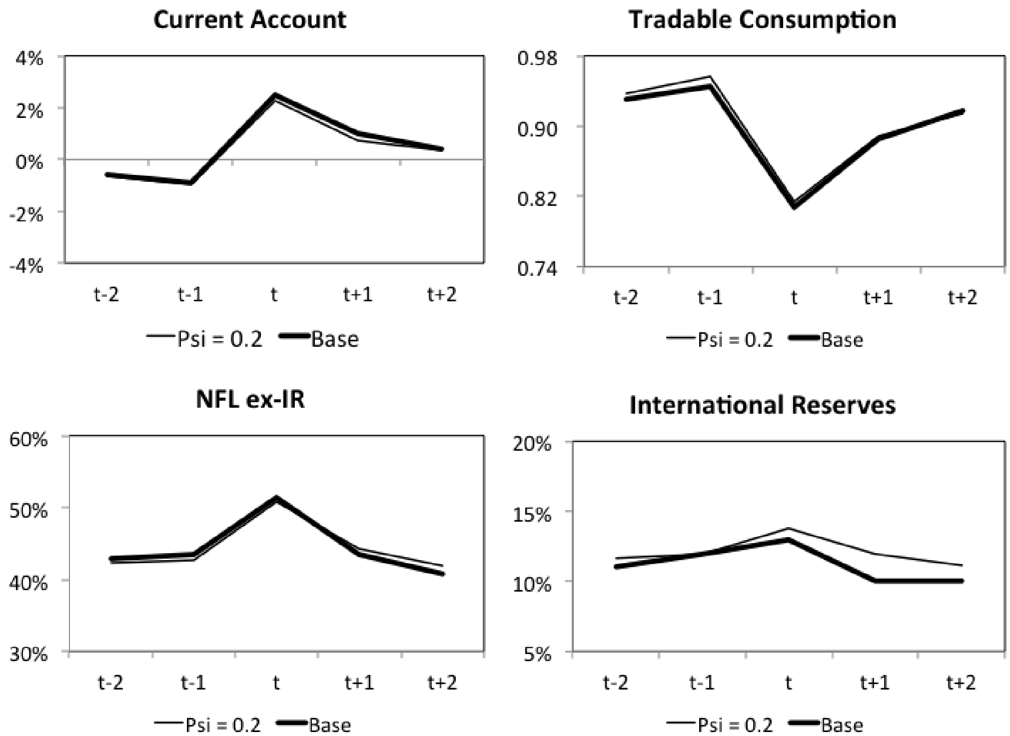

Figure 2.13: Macro Dynamics around Sudden Stops Events - Lower ψ

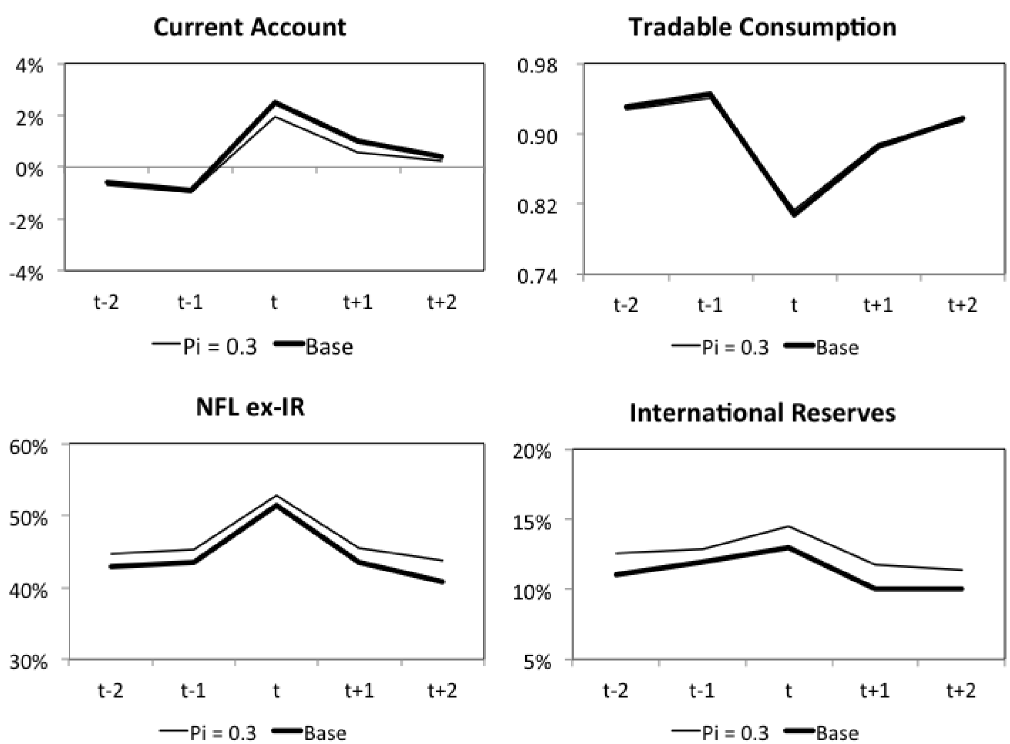

Figure 2.14: Macro Dynamics around Sudden Stops Events - Higher π

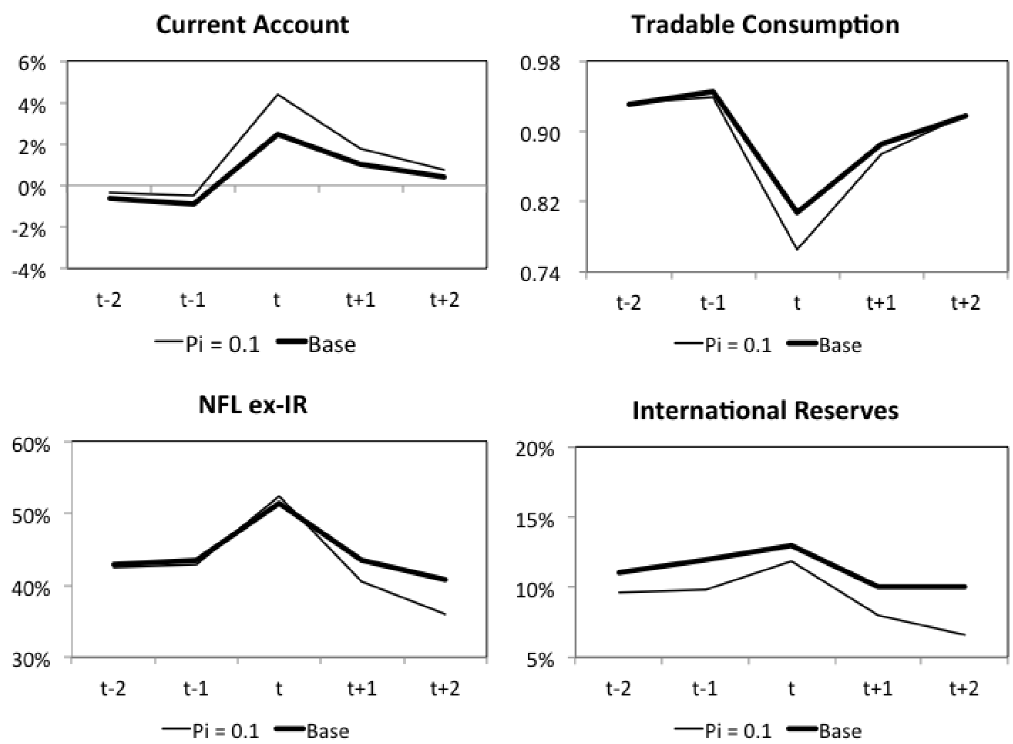

Figure 2.15: Macro Dynamics around Sudden Stops Events - Lower π

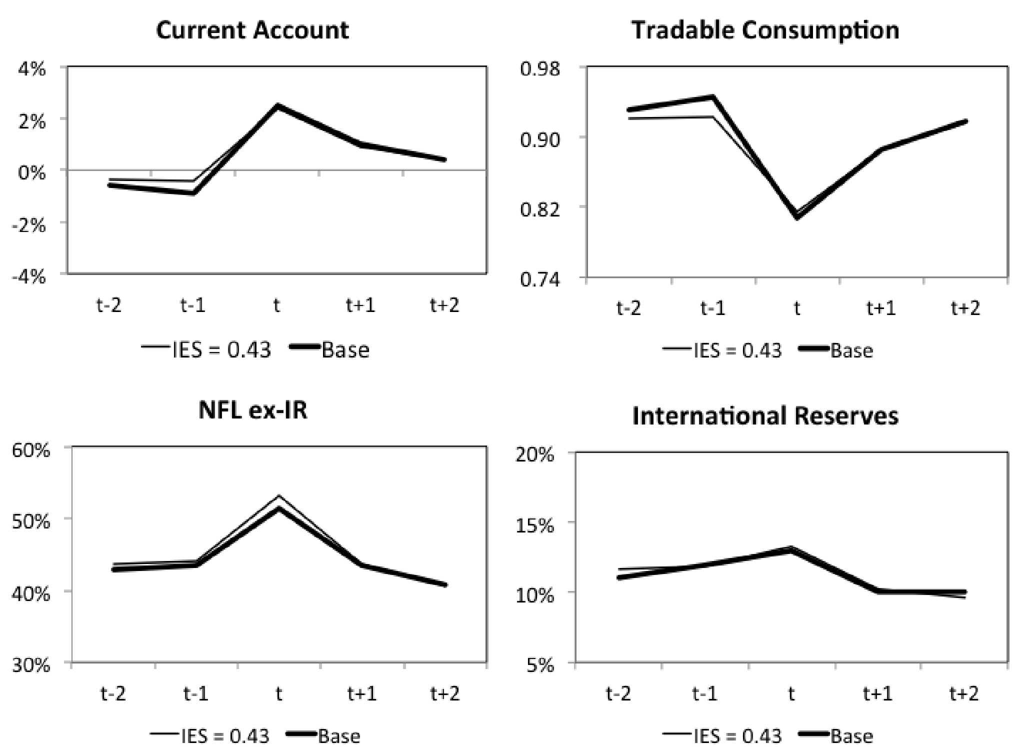

Figure 2.16: Macro Dynamics around Sudden Stops Events - Lower ES

2.6 Conclusion

Why emerging markets hold very high levels of international reserves and short-term foreign liabilities simultaneously? This work explains this puzzling fact by explicitly introducing international reserves as collateral for external borrowing in a dynamic, stochastic model of a small open economy with credit constraints subject to exogenous financial shocks.

I find that the model can explain the observed average level of reserves to GDP ratio in Latin America without considering any additional motives for reserve accumulation. Moreover, the optimal policy implies that the government accumulates reserves before a Sudden Stop and there is a small depletion during it. Finally, the welfare implications of the optimal policy are quite similar to those of a policy of constant international reserves, which sheds some light on the fear of losing reserves observed in the recent Global Financial Crisis.

It is important to emphasize that I abstract from some potentially important features of models where foreign liabilities and international reserves are chosen together. First, I don't consider the role of international reserves to reduce output costs in Sudden Stops. Including this feature would unambiguously lead to an increase in the optimal level of reserves. Second, I don't consider the possibility of sovereign default. On the one hand, Alfaro and Kanczuk (2009b) show that holding international reserves increase the country's willingness to default and consequently make external debt more costly. On the other hand, Levy Yeyati (2008) argues that international reserves reduce the probability of default during crises and consequently reduce spreads in external borrowing. Therefore, the effect of reserve accumulation in the cost of external borrowing when we allow for sovereign default is still debatable. Finally, I abstract from any exchange rate management policies, which might be another important motive for reserve accumulation.

The role of international reserves as collateral for foreign borrowing is an important and not explored aspect in the recent process of international reserves accumulation by emerging economies, which is still a puzzle in the international economics literature. The policy implications of this feature and its potential consequences for the policies pursued by Multilateral Institutions such as the IMF and Central Banks around the world make it an important area for future research.

Chapter 3

The Real Consequences of Countercyclical Capital Controls

3.1 Introduction

Since the onset of the Latin American crisis of the late 1990s, there has been a renewed support for the use of capital controls in periods of capital bonanza. Even the IMF, formerly known to support capital account liberalization, has recently emphasized that controls on capital inflows should be considered as part of the Emerging Economies policy toolkit (Ostry et al. (2011)). However, most of the papers that conclude that the imposition of taxes in capital inflows might be optimal find small welfare gains and do not explicitly consider capital accumulation decisions (see for example Bianchi (2011)).

The primary goal of our paper is to empirically evaluate the effects of capital controls on fixed investment using both macro and micro data. We evaluate the effects of several capital controls measures implemented by the Brazilian Government since 2009. We focus on Brazil because it is the most prominent case of countercyclical capital controls.[1] Moreover, financial markets in Brazil are liquid, well developed, and open to foreign capital flows, leading to a clearer connection between the controls and the real economy.

To formally study the effects of these measures, we first follow the methodology of Abadie and Gardeazabal (2003). We use a combination of other countries with similar characteristics to Brazil to construct a synthetic control country. The control country is calibrated to match Brazilian macroeconomic data *before* the imposition of controls. With that in hand, we can then construct a counterfactual that will be compared to the actual data to evaluate the impact of the measures on real activity.[2] We find that capital controls had negative effects on both investment and consumption in Brazil, with the former

1. Fernández, Rebucci, and Uribe (2015) examine the behavior of capital controls in a large number of countries over the period 1995-2011 and find they are remarkably acyclical and that the Brazilian case is an unusual one, as on average countries did not did not appeal to capital control measures to counteract the capital inflows on the pre-great-contraction period.

2. Jinjarak, Noy, and Zheng (2013) use the same methodology to evaluate the effects of Brazilian Capital Controls throughout 2008-11 but they focus solely on the impact on equity flows and on the exchange rate in the short-run. Carrasco, De Mello, and Duarte (2014) also use this methodology applied to Brazilian data but they focus on the period between 2003-12 to evaluate the performance of the Brazilian economy among different dimensions.

being close to 20% higher, and the latter being 12% higher in the synthetic country. We found no significant real effects on exports and imports.

To confirm these results at a microlevel and identify the types of firms more affected by the controls, we then use the Worldscope database on almost 300 Brazilian firms. We take a reduced form approach to see what the effects of capital controls on investment were at the firm level. We supplement the data available on Worldscope with data from the Brazilian Development Bank (BNDES) to check the degree to which different firms took advantage of subsidized loans from the BNDES to counteract this credit supply shock. We also use export data to evaluate whether firms that export more benefited from the imposition of capital controls in any particular way. What we find, robust to a host of different specifications, is that investment over assets unambiguously declined by as much as 40% after the imposition of capital controls. Further we find that firms that had access to cheaper credit from the BNDES were able to offset that decline almost completely.

We are additionally able to use the results from the first section as a novel control. We would like to run the regressions on the micro data while controlling for macroeconomic shocks or circumstances that would have impacted Brazil apart from capital controls. In fact, we can do exactly that by using the synthetic levels of investment as calculated by the synthetic control method. This captures any patterns in investment that would have affected all commodity producing/exporting nations that did not impose any controls during this period.

Separating the sample into classes, we find that the results are not sensitive to the size of the firm: in percentage terms, it appears that firms were relatively equally affected. If we then split the sample into groups based on how much firms export, we find that firms that export more were relatively unaffected by the capital controls - their investment did not decline significantly, nor did they BNDES loans help them significantly. However, firms that did not export very much were significantly affected by both. This points to the capital controls having a very targeted goal: to support exporters, potentially at the expense of other firms. Brazil, at the time, was concerned with a rapidly appreciating exchange rate, which would have hurt exports - by imposing controls, Brazil avoided this problem, but the resultant investment drop was big enough to lead to an overall contraction. Moreover, helping exporters did not lead to higher export volumes as we can see from the results in the macro section.

The combination of these analyses, with aggregate macro and disaggregated micro data, lead us to conclude that the capital control policies enacted by Brazil did not have uniformly positive effects. There may have been some benefits in stabilizing the exchange rate and price level, which has been measured in other works. However, our work is, as far as we know, one of the few to examine the effects of such controls on real variables such as consumption and investment, and we find that the effects are strongly negative, and asymmetric. This should call for a reexamination of such policies, where modeling accounts not only for the price effects but also the investment effects to gauge the overall welfare impact of such policies.

Related Literature. This paper is related to a recent theoretical literature that advocates that controls on capital flows and, more broadly, macroprudential measures might be desirable in some contexts (Ostry et al. (2011), Bianchi (2011), Korinek (2011), Schmitt-Grohé and Uribe (2015a), Farhi and Werning (2012), Costinot, Lorenzoni, and Werning (2014) and many others) to curb what are called ′excessive′ capital flows. This literature is based on the notion that there are externalities associated with external borrowing because individual market participants do not internalize their contribution to aggregate financial instability and ′overborrowing′ in a foreign currency might arise. Thus prudential capital controls - tightening of restrictions on net capital inflows during booms and their relaxation during recessions - might be desirable to induce private agents to internalize this externality, and improve total welfare. This is not a new idea, as it goes back to Tobin (1978) seminal paper. However, most of this literature abstracts from the effects on investment and its impact on welfare. Our paper tries to fill this gap by giving an estimate of the potential effects on investment that might help to complete an evaluation of its welfare effects.

It is also related to papers that analyze the effectiveness of capital controls. Magud, Reinhart, and Rogoff (2011) provide a thorough survey of this literature and find that capital controls on inflows seem to make monetary policy more independent, alter the composition of capital flows, and reduce real exchange rate pressures. Klein (2012) differentiates among episodic and long-standing capital controls and finds that only the latter have some effect on growth of certain financial variables and with GDP growth. However, he also points out that these differences seem to arise from the fact that countries with long-standing controls on capital inflows are also poorer than the other countries in the sample. Andreasen, Schindler, and Valenzuela (2015) study the effects of capital controls on corporate bond spreads and find that restrictions on capital inflows produce a substantial and economically meaningful increase on them, which supports our results regarding real investment. Finally, Forbes (2007) finds that the Chilean capital controls during the 90's increased financial constraints, especially for smaller traded firms. Our paper contributes to this strand of the literature by focusing on real variables and finds that there were significant real effects of controls, which is at odds with most of the previous literature.

Finally, there are some other papers that also study the particular case of Brazil after the Global Financial Crisis. Chamon and Garcia (2016) document that the capital controls measures in Brazil had some success in segmenting Brazilian and global financial markets, but they do not find significant effects in the exchange rate. Jinjarak, Noy, and Zheng (2013) also employ a synthetic control methodology but they focus mainly on the effects on capital inflows and were not able to find any significant effect. Finally, Alfaro, Chari, and Kanczuk (2016) examine the effects of these measures on firm-level stock returns and real investment and find a significant drop in cumulative abnormal returns for Brazilian firms following capital control announcements, with large firms and largest exporting firms appearing to be less affected. They do not find any statistically significant change in investment for the whole sample but, when they split the sample, they find that there was a significant fall in investment for small and non-exporting firms while exporting firms saw a statistically significant rise in their investment rates. Although they also focus on firm-level investment, they employ an event-study methodology which do not control for changes in investment opportunities or the huge increase in provision of subsidized credit. Our contribution is to show that, even controlling for all these facts there still was a significant decline in firm investment after the imposition of controls.

Layout. The rest of the paper is organized as follows. Section 3.2 provides a quick view of capital controls measures in Brazil to contextualize this work. Section 3.3 describes the macroeconomic approach and its results. Section 3.4 describes the microeconomic approach and its results. Section 3.5 concludes.

3.2 A Look at the Brazilian Case

Brazil has a long history of capital controls measures. In the 1990s, a wave of current account liberalization started. Minella and Goldfajn (2007) state that

> The liberalization was a gradual process of establishing new rules on capital inflows and outflows. The result of the liberalization process was (a) reduction or elimination of taxes on foreign capital financial transactions and of minimum maturity requirements on loans; (b) elimination of quantitative restrictions on investments by nonresidents in financial and capital markets securities issued either domestically or abroad; (c) permission for residents to issue securities abroad, including debt, without prior approval by the Central Bank; (d) more freedom for residents to invest in FDI and portfolio abroad;

and finally (e) the introduction of currency convertibility, initially through the mechanism of international transfers in Reais, whereby residents could transfer their resources abroad through the use of nonresident accounts.

This period of a more open capital account came to an end in 2008 due to massive foreign inflows. After some short-lived controls in the beginning of 2008, the Brazilian Government imposed a long list of measures beginning in October 2009 due to the unprecedented measures of unconventional monetary policy taken by advanced economies policy makers after the Global Financial Crisis, which were labeled later by Brazilian President Rousseff as a "monetary tsunami that have led to a currency war and have introduced new and perverse forms of protectionism in the world". These measures are the focus of this paper and are described in detail in Table 3.1.[3]

Date	Capital Control Measures
10/19/09	2% tax on portfolio inflows (equity & fixed income)
11/18/09	1.5% tax on the conversion of ADRs into local equities
10/04/10	Tax on fixed income inflows raised to 4% tax
10/18/10	Tax on fixed income inflows raised to 6% tax
01/06/11	Unremunerated reserve requirement on bank FX positions > US$ 3 billions
03/28/11	6% entry tax on foreign loans with maturity below 1 year
04/06/11	6% entry tax on foreign loans with maturity below 2 years
07/08/11	Unremunerated reserve requirement on bank FX positions > US$ 1 billion
07/26/11	1% tax on long notional Brazilian Real derivatives positions
12/01/11	Elimination of tax on portfolio equity inflows
02/29/12	6% entry tax on foreign loans with maturity below 3 years
03/01/12	Restrictions on anticipation of exporter payments for up to 1 year
03/09/12	6% entry tax on foreign loans with maturity below 5 years
03/15/12	Tax on derivatives set to zero for hedging by exporters
06/13/12	6% entry tax on foreign loans restricted to maturities below 2 years
12/04/12	Anticipation of exporter payments for up to 5 years are allowed
12/05/12	6% entry tax on foreign loans restricted to maturities below 1 year
06/04/13	Elimination of tax on fixed income flows

Source: Adapted from Chamon and Garcia (2016).

Table 3.1: Capital Controls Measures in Brazil - 2009-2012

As noted by Chamon and Garcia (2016), these measures were successful in

3. We did not start our analysis in 2008 because the measures at that time were in place for a very brief period due to the bankruptcy of Lehman Brothers. Moreover, it would be hard to disentangle the effects of the controls from those of the Global Financial Crisis.

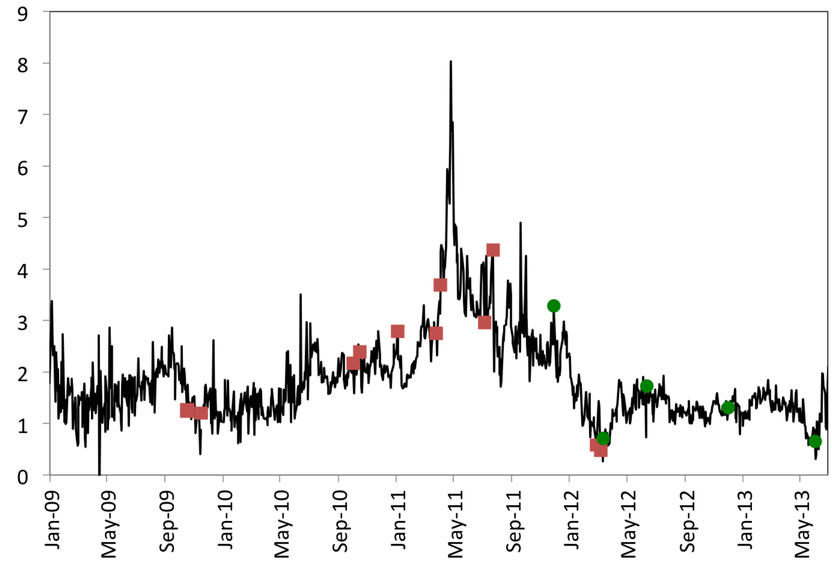

Figure 3.1: 90-Day Cupom Cambial (Spread Between Onshore and Offshore Dollar Rates - %)
Note: Red squares are a tightening in capital controls and green circles are a loosening in capital controls. Source: Bloomberg.

segmenting the Brazilian and global financial markets. Figure 3.1 shows the spread between onshore and offshore dollar rates. The spreads had been relatively small, around 1%, but had a huge increase after the October 2010 measures, coming back to previous levels only after the loosening measures of early 2012. Moreover, as we can see in Figure 3.2, after the October 2010 measures portfolio inflows also declined sharply while foreign direct investments actually increased and other investments were not affected.[4]

There seems also to exist a close relation between the capital controls measures and a strong slowdown in GDP growth and investment (see Figures 3.3 and 3.4). The slowdown occurred both in capital goods production and, to a lesser extent, in capital goods imports, which might indicate that the effect of controls were more pronounced in the financing of capital goods purchases and not only on the financing of imports themselves (see Figure 3.5).

Given all this preliminary evidence, we proceed in the next sections to evaluate more

4. The increase in foreign direct investments might be related to some relabeling of flows to circumvent the controls but the Brazilian Central Bank denies that.

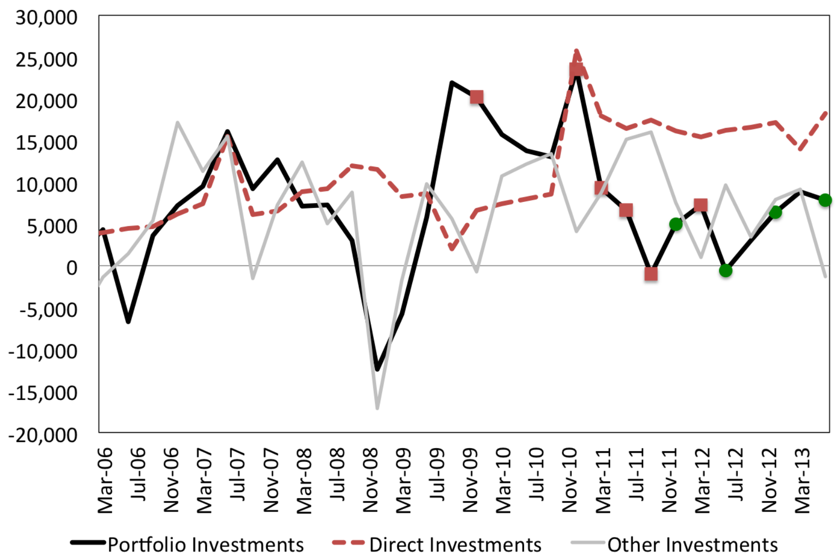

Figure 3.2: Brazil - Foreign Net Inflows (Seasonally Adjusted)

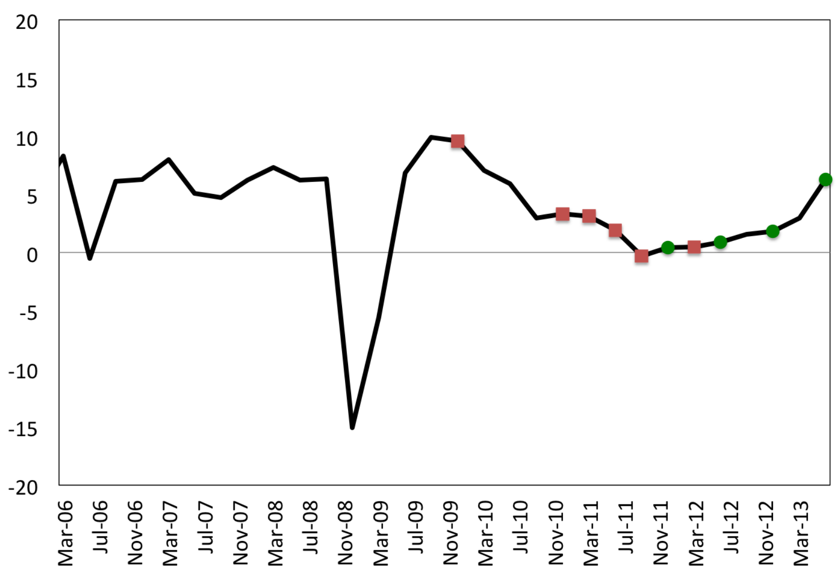

Figure 3.3: Brazil - GDP (Annualized Quarterly Change)

formally the relationship between the capital controls measures in Brazil and the real economy.

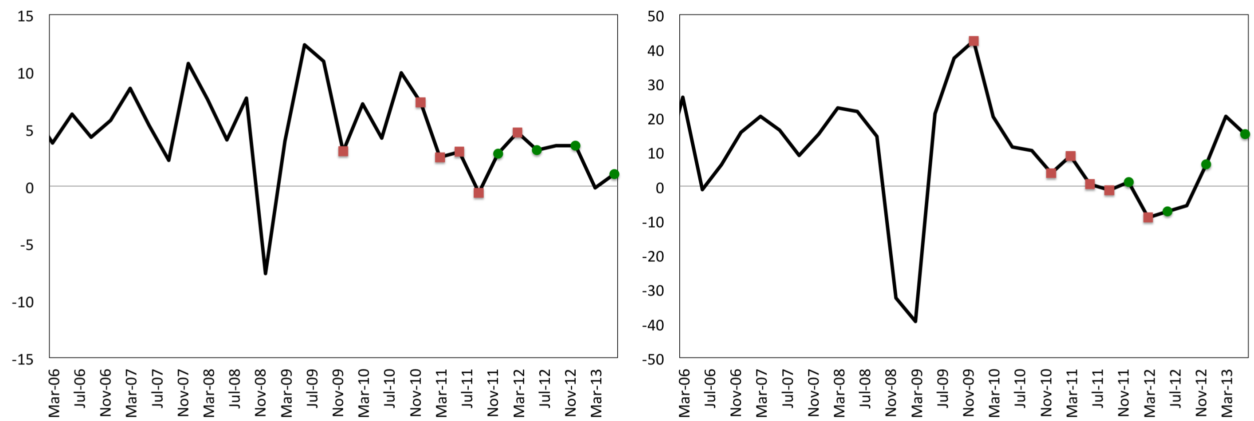

Figure 3.4: Brazil - Private Consumption and Fixed Investment (Annualized Quarterly Change)

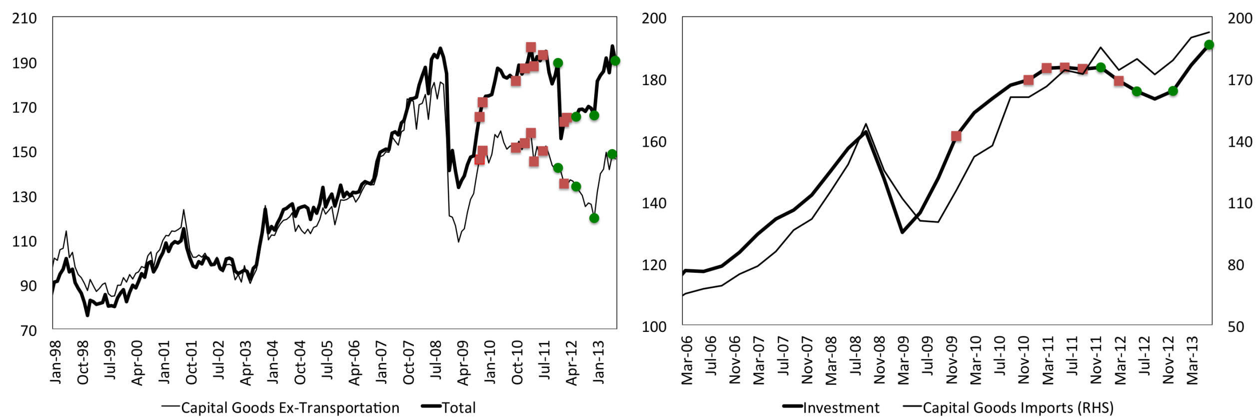

Figure 3.5: Brazil - Capital Goods Production/Capital Goods Imports and Fixed Investment (Annualized Quarterly Change)

3.3 Macroeconomic Approach

3.3.1 Empirical Strategy

Looking at Figures 3.3-3.5, it seems evident that Brazil's imposition of capital controls stunted growth just as it was rebounding from the 2008 crisis. In this section, we formally analyze the connection between these measures and the real economy. To facilitate this, we try to answer the question - what would have happened to Brazil's real macroeconomic aggregates had capital controls *not* been introduced? Brazil is a unique economy, but not so much so that we cannot learn from other countries which are subject to similar shocks.

We approach the issue by comparing the economic events in Brazil to a weighted average of countries that are comparable to Brazil. The general methodology is taken from Abadie and Gardeazabal (2003). By weighting other countries to match the macroeconomic characteristics of Brazil, we will achieve what we term a synthetic Brazil that did not impose capital controls. The difference in investment paths upon Brazil's institution of capital controls will be the real effect of capital controls.

More formally, let N be the number of countries in our sample and $W = (w_1, ..., w_N)'$ be a vector of nonnegative weights such that $\sum w_j = 1$, where w_j represents the weight of country j in the synthetic country. Our objective is to construct a counterfactual for the desired variable, which would be given by $Y_1^* = Y_0 W^*$. To do that, we will consider M many macroeconomic factors, to which we will try to match our weighted synthetic Brazil. These factors are pre-treatment[5] average data such as the real interest rate, GDP, foreign direct investment, and others. Let us call X_0 the $N \times M$ matrix that houses all of the macroeconomic data for all of the countries in our sample before the imposition of controls i.e., the vectors of pretreatment characteristics for untreated countries. Further let us call X_1 the $1 \times M$ vector of the macroeconomic variables for Brazil i.e., the vector of pretreatment characteristics for the treated country. Finally let V be a diagonal matrix with non-negative components whose elements reflect the relative importance of each characteristic. Then $W = \{w_1, ..., w_N\}$ is selected to minimize the following expression:

$$W^*(V) = arg \min_{w \epsilon W} \sqrt{(X_1 - X_0 W)' V (X_1 - X_0 W)}$$

The choice of V could be subjective but we try to do it optimally following Abadie and Gardeazabal (2003). Let Y_1 be the vector of time-series for the objective variable in Brazil before the imposition of controls i.e., the vector of pretreatment time-series for the treated country, and Y_0 be the vector of the same time series for the other countries in the

5. Pre-treatment means before the imposition of capital controls in our case.

same period. To choose V optimally, we minimize the MSE for the pre-treatment period [6]:

$$V^* = arg \min_{v \epsilon V} \sqrt{(Y_1 - Y_0 W^*(V))'(Y_1 - Y_0 W^*(V))}$$

3.3.2 Country Selection and Sample Period

For our sample, we must choose countries that have similar characteristics to the Brazilian economy. Thus, the sample must include both Latin American countries and other commodities producers, which arguably might be subject to the same shocks that Brazil suffered after the Global Financial Crises. We also include the USA as the crises was originated there but, as we will see later, its inclusion is not relevant as it gets zero weights for all variables hereby analyzed. This leaves us with a sample of 10 countries: Argentina, Chile, Ecuador, Mexico, Peru, Uruguay, Australia, Canada, New Zealand and USA.

For the sample period, to minimize the possible effects of confounding factors and to have the same amount of data before and after the controls, we restrict our attention to the 15 quarter before and after the controls: 2006:1 to 2013:2.

3.3.3 The Effects on Real Investment

We begin our analysis by evaluating the effects of capital controls on real fixed investment. First, we must decide which characteristics to include as our target pre-treatment moments. We choose the following characteristics: GDP per capita, real GDP growth, investment to GDP ratio, the share of capital goods imports in total imports, current account to GDP ratio and FDI to GDP ratio. The first two characteristics are important to get a synthetic counterpart with the same level of economic

6. Alternatively, we could choose other weighting matrices such as one that gives the same weight for all countries.

development, as it is well documented that poorer countries tend to invest more than richer ones. The investment to GDP ratio controls for the level of investment before the treatment. The share of capital goods imports controls for the reliance of the country in foreign capital goods. It is a well known fact that developing countries rely more on imported capital goods than developed economies and thus it is important to take this characteristic into consideration. The current account to GDP ratio and the FDI to GDP ratio measure the reliance on external savings to fund investments and consequently are also important characteristics to be considered. Finally, we also consider the change in the commodity price export index as there is some evidence that the behavior of these economies are closely related to it.[7]

The countries with nonzero weights are Uruguay (58.6%), Argentina (30.6%), Peru (5.7%) and Ecuador (5.2%). The results are shown in Table 3.2 and Figure 3.6. As we can see, the synthetic Brazil is able to match the pre-treatment characteristics of Brazil and the investment time series. Moreover, the level of investment in synthetic Brazil is significantly higher at the end of the period, with a gap of around 18%.

Real Fixed Investment	Brazil	Synthetic Brazil
GDP per capita (PPP)	9236	11034
Real GDP growth	4.2	5.2
Investment (% of GDP)	20.6	20.6
Capital Goods Imports (% of total)	37.3	32.5
Current Account (% of GDP)	-0.3	-0.3
FDI (% of GDP)	1.1	4.6
Commodity Exports Price (Average % change)	2.7	1.8

Table 3.2: Pre-Capital Controls Imposition Characteristics - 2006:1-2009:3

7. We construct real commodity export prices for each country following a methodology similar to Deaton and Miller (1996). The methodology is composed by 5 steps: (i) we find the equivalence between SITC level 4 groups and the IMF commodities database (composed by 51 commodities); (ii) we calculate for each country the value of each primary commodity exports using the UN COMTRADE database, which provides annual trade data for SITC level 4 groups, and take the average; (iii) we calculate the weights for each commodity by dividing its average value of exports for each commodity by the average total value of primary commodity exports; (iv) we use the weights to compute a geometric weighted-average of (US-dollar based) monthly nominal commodity export prices; and (v) we calculate the real commodity price index by dividing the nominal price index by the U.S. import price of manufactured articles from industrialized countries.

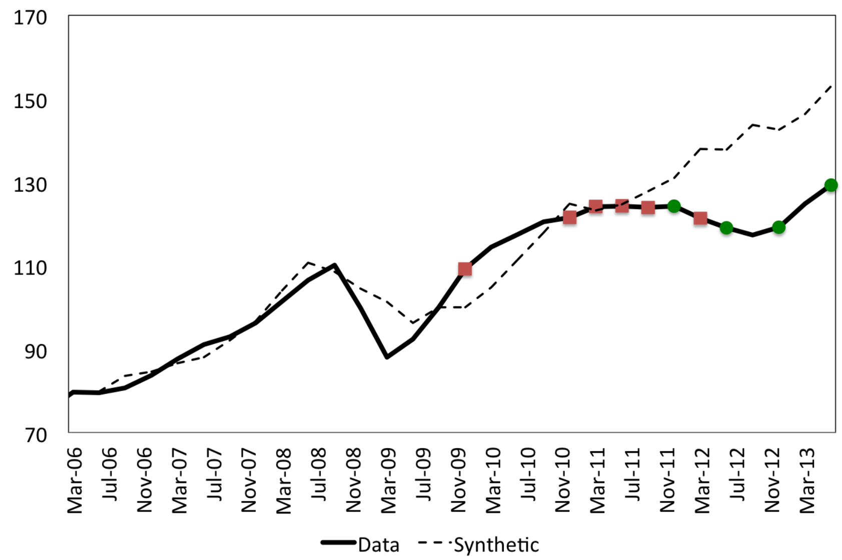

Figure 3.6: Real Fixed Investment - Brazil vs Synthetic Brazil

To check the significance of our results, we run what is called a placebo test, applying the methodology described before to all the untreated countries. As we can see in Figure 3.7, the effect in Brazil is significantly different than what we get for other countries, especially after the October 2010 measures, which is coherent with the evidence in foreign cost of capital shown in Section 3.2.

Finally, we also verify the robustness of our results by excluding from the original sample the two countries with the biggest weights, separately. As we can see in Figure 3.8, the results are note very sensitive to the exclusion of these countries.

3.3.4 The Effects on Real Consumption

We now repeat the exercise to consumption, choosing as characteristics GDP per capita, real GDP growth, consumption to GDP ratio, inflation, share of consumption goods imports to total imports and investment to GDP ratio. Again, the first two characteristics are important to get a synthetic counterpart with the same level of economic development as poorer countries usually have a different profile of consumption than richer countries. The former are more tilted towards goods while the

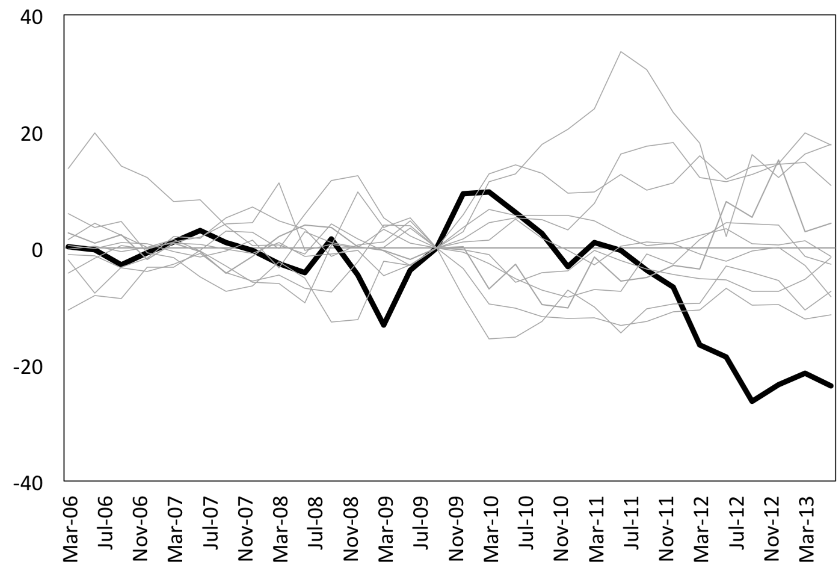

Figure 3.7: Real Fixed Investment - Placebo Gaps

Note: The thick black line represents the gap between real and synthetic data data for Brazil while the light gray lines represent the gap for all other countries in the sample.

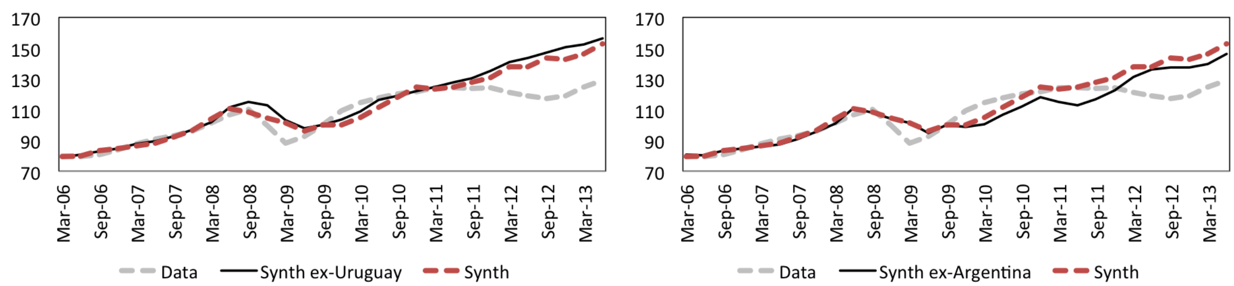

Figure 3.8: Real Fixed Investment - Brazil vs Synthetic Alternatives

latter toward services. Inflation is known to be an important determinant of consumption expenditures in the short run. The consumption to GDP ratio controls for the level of consumption before the treatment. We also include investment to GDP ratio to have an economy with similar spending profile. The share of consumption goods imports controls for the reliance of the country in foreign consumption goods. Finally, we target the change in the commodity price export index as there is some evidence that the behavior of these economies are closely related to it.

The countries with nonzero weights are now Peru (70.4%), Uruguay (19.9%) and Argentina (9.7%).The results can be seen in Table 3.3 and Figure 3.9. As we can see, the synthetic Brazil is able to match most of the pre-treatment characteristics of Brazil and the consumption time series. Again, the level of consumption in synthetic Brazil is higher at the end of the period, but now the gap is somewhat smaller, around 12%.

Real Private Consumption	Brazil	Synthetic Brazil
GDP per capita (PPP)	9236	8665
Real GDP growth	4.2	6.3
Inflation	4.6	4.6
Consumption (% of GDP)	70.2	64.2
Investment (% of GDP)	20.6	21.8
Consumption Goods Imports (% of total)	12.3	17.0
Commodity Exports Price (Average % change)	2.7	2.7

Table 3.3: Pre-Capital Controls Imposition Characteristics - 2006:1-2009:3

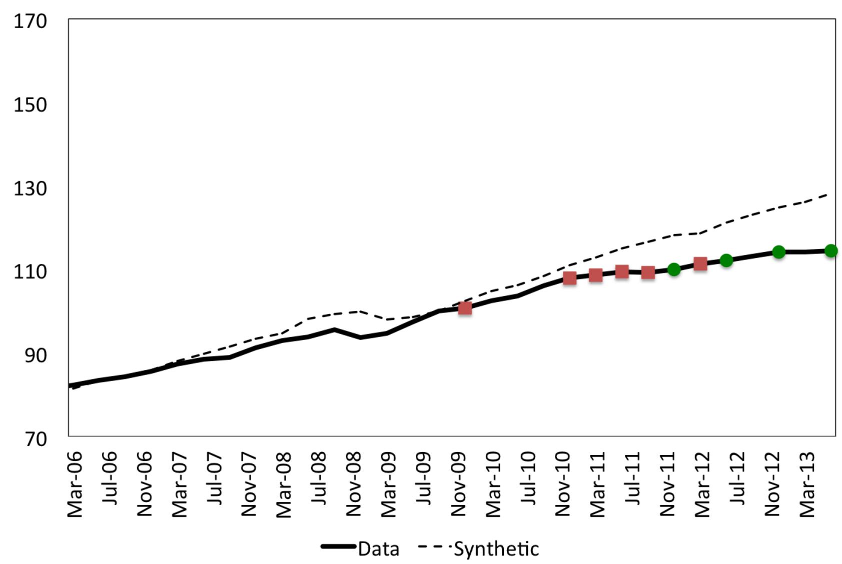

Figure 3.9: Real Private Consumption - Brazil vs Synthetic Brazil

We run again the placebo test, applying the methodology described before to all the untreated countries. As we can see in Figure 3.10, again the effect in Brazil is different than what we get for other countries, especially after 2011. However, we now have one of the placebos closer to the Brazilian gap, which might indicate less significant results.

We exclude again from the original samples the two countries with the biggest weights, separately, to verify the robustness of our results. As we can see in Figure 3.11,

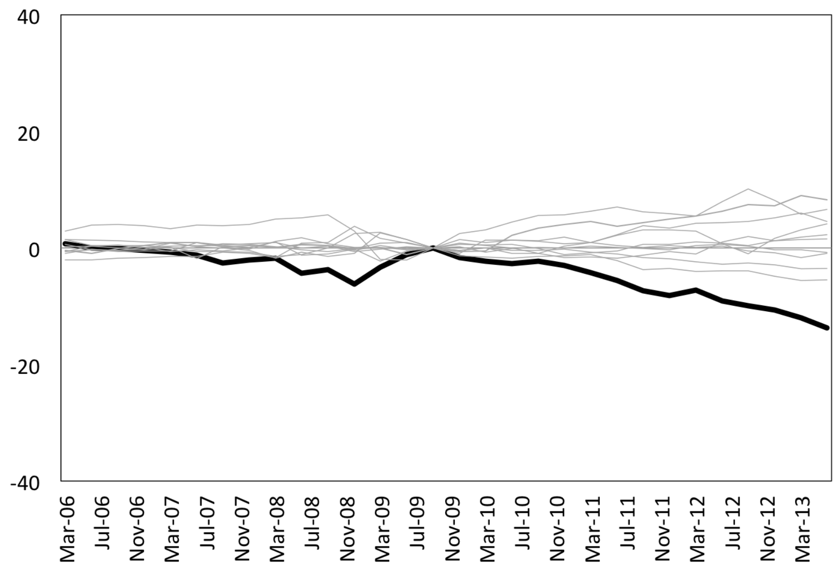

Figure 3.10: Real Private Consumption - Placebo Gaps

Note: The thick black line represents the gap between real and synthetic data data for Brazil while the light gray lines represent the gap for all other countries in the sample.

the results are somewhat sensitive to the exclusion of Peru, but the level of synthetic consumption is even higher than before, which would indicate a stronger effect of controls on consumption.

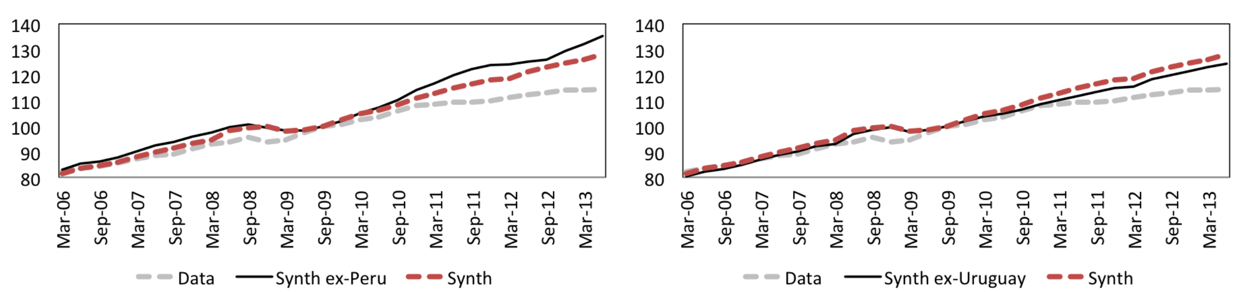

Figure 3.11: Real Private Consumption - Brazil vs Synthetic Alternatives

3.3.5 The Effects on Real External Variables

Finally, we evaluate what the effects of capital controls were in the external real sector, repeating the exercise for exports and imports. We choose as characteristics GDP per capita, real GDP growth, investment to GDP ratio, consumption to GDP ratio and shares of consumption and intermediate goods exports or imports for each case. The first two characteristics controls for the level of economic development for the same reasons we had for investment and consumption. The investment and consumption to GDP ratios are used to have an economy with similar spending profiles. The shares are important to get a synthetic country with the same exports and imports profile. Finally, we also control for the change in the commodity price export index as there is some evidence that the behavior of these economies and especially its external sector is closely related to it.

The countries with nonzero weights for exports are Mexico (45.1%), Argentina (32.1%) and Chile (22.9%) and for imports are Chile (50.6%), Peru (22.6%), Mexico (15.6%) and Uruguay (11.3%). The results are shown in Tables 3.4 and 3.5 and Figure 3.12. As we can see, the synthetic Brazil is able again to match well most of the pre-treatment characteristics of Brazil and the exports and imports time series. However, the results now are much weaker. In fact, as we can see in Figure 3.13, running the placebo test lead us to conclude that the effect in Brazil for the external sector is not much different than what we get for other countries, which indicates that there weren't significant effects from the capital controls.

Exports Volume	Brazil	Synthetic Brazil
GDP per capita (PPP)	9236	12892
Real GDP growth	4.2	2.9
Investment (% of GDP)	20.6	22.9
Consumption (% of GDP)	70.2	61.9
Consumption Goods Exports (% of total)	28.5	26.1
Intermediate Goods Exports (% of total)	47.9	48.0
Commodity Exports Price (Average % change)	2.7	2.5

Table 3.4: Pre-Capital Controls Imposition Characteristics - 2006:1-2009:3

We also verify the robustness of our results again by excluding from the original samples the countries with the biggest weights, separately. As we can see in Figures 3.14 and 3.15, the results are somewhat sensitive to the exclusion of Argentina for exports but they are still within the range where we would conclude that there was no significant

Imports Volume	Brazil	Synthetic Brazil
GDP per capita (PPP)	9236	12859
Real GDP growth	4.2	4.4
Investment (% of GDP)	20.6	21.4
Consumption (% of GDP)	70.2	61.3
Consumption Goods Imports (% of total)	12.3	16.0
Intermediate Goods Imports (% of total)	50.4	47.2
Commodity Exports Price (Average % change)	2.7	2.3

Table 3.5: Pre-Capital Controls Imposition Characteristics - 2006:1-2009:3

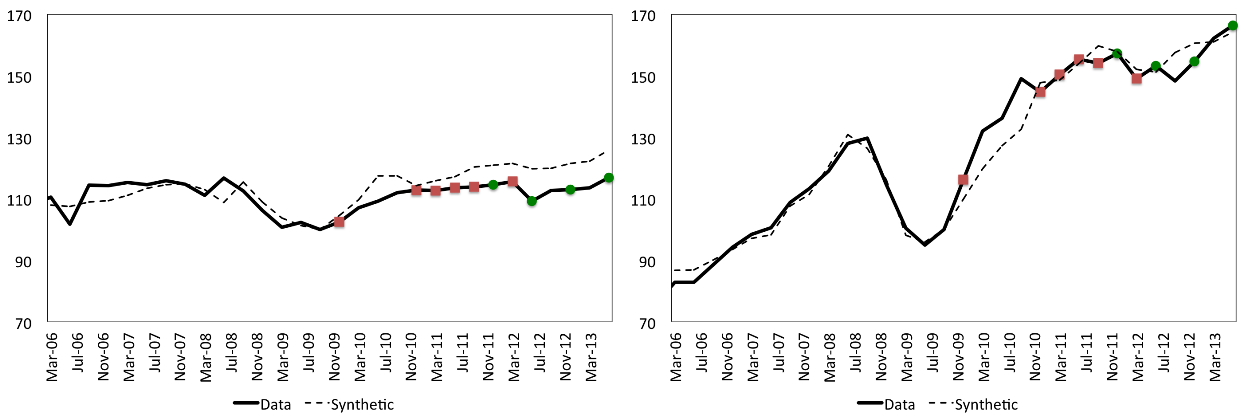

Figure 3.12: Real Exports and Imports - Brazil vs Synthetic Brazil

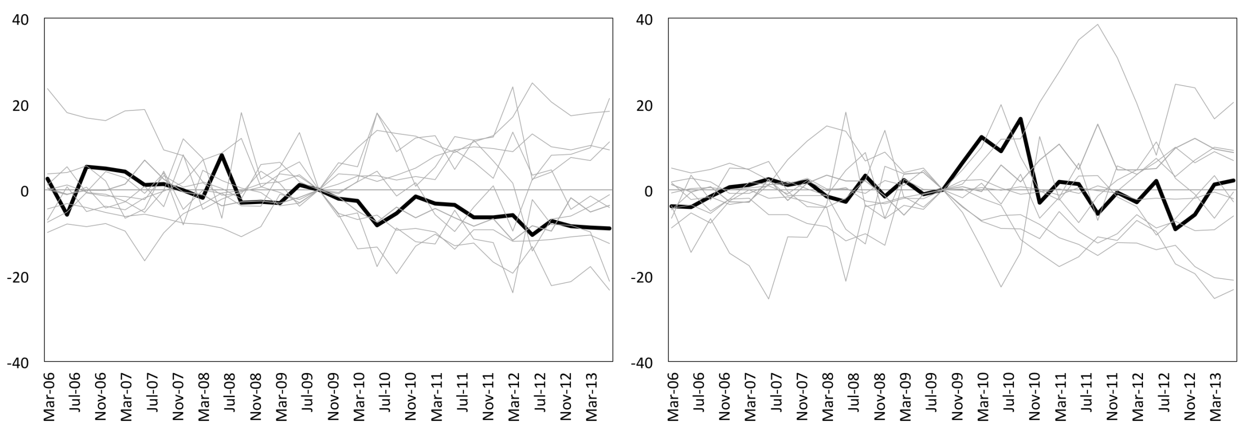

Figure 3.13: Real Exports and Imports - Placebo Gaps

Note: The thick black line represents the gap between real and synthetic data data for Brazil while the light gray lines represent the gap for all other countries in the sample.

effect of the controls on them.

This section shows that capital controls had negative effects on both investment and consumption in Brazil, with stronger and more significant effects in the former, and no

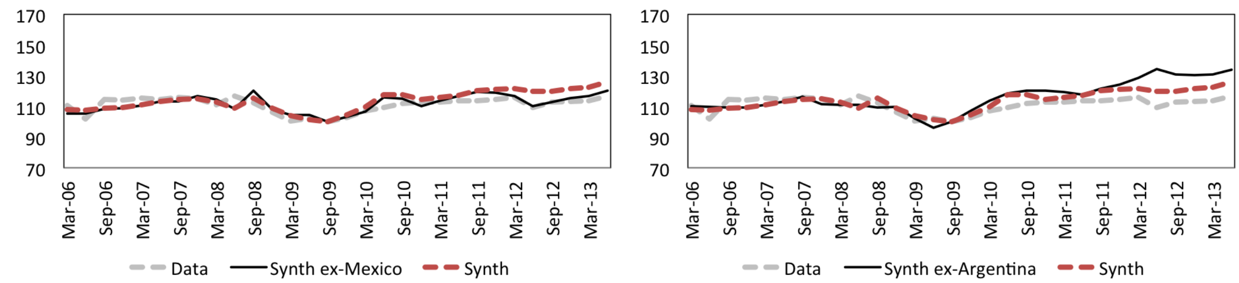

Figure 3.14: Real Exports - Brazil vs Synthetic Alternatives

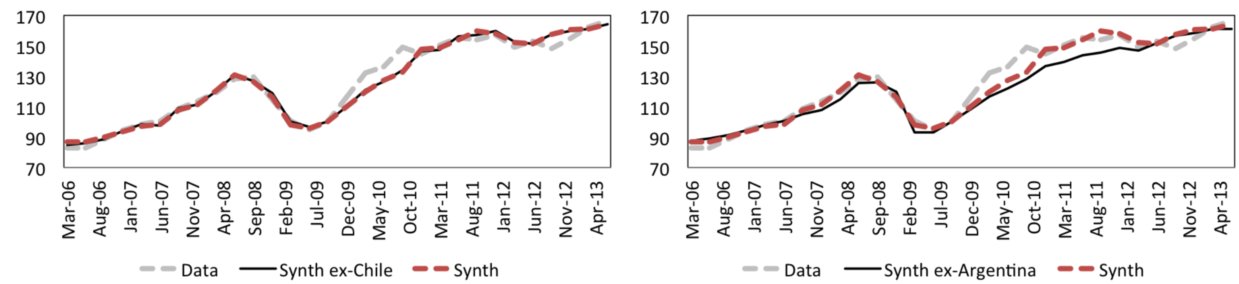

Figure 3.15: Real Imports - Brazil vs Synthetic Alternatives

significant effects on external real variables. These results might be important to evaluate the welfare impacts of capital controls, which gained renewed support since the Global Financial Crisis. We will now use microeconomic data to check whether we get similar conclusions using firm level data and identify the types of firms that were more affected by the imposition of controls.

3.4 Microeconomic Approach

3.4.1 Empirical Strategy

There are many potential models that we could derive here to generate estimating equations, but that is not the objective of this work. Our objective is to provide a quantification of the impact of capital controls, rather than a micro foundation. Our main estimating equation is:

$$Inv_{it} = \beta_1 Inv_{it-1} + \beta_2 \text{After} + \beta_3 \text{After*BNDES}_{it} + \beta_4 \text{Control Variables}_{it} + \eta_i + \lambda_t + \epsilon_{it}$$

Inv_t is investment over total assets at time t. After is an indicator variable that is one since 2010 and 0 before. After*BNDES is one for every year after 2009 that an individual firm received a BNDES (Brazilian Development Bank) loan, and is zero everywhere else.[8] We have different control variables for firms future investment opportunities (proxies for the marginal product of capital) - the two we will show here are cash-flow over total assets, and Tobin's q. Our specification is similar to Duchin, Ozbas, and Sensoy (2010). All variables will be fully described, with summary statistics, in the Data section below.

We are positing a story that capital controls had the real effect of constricting investment. We would initially expect $\beta_1 > 0$, given the strong documented importance of lagged investment on current investment spending (see for example Gilchrist and Himmelberg (1995) and Eberly, Rebelo, and Vincent (2012)). Additionally, given our story we would expect $\beta_2 < 0$, that is, that investment after the imposition of controls would be significantly lower than before. However, if the reason for the drop in investment were a negative credit supply shock, as we assume, then we would also expect $\beta_3 > 0$ as firms who had access to subsidized credit lines were not hit as hard by the controls as firms who did not.

Clearly the main estimating equation cannot be executed using simple OLS, as there are many issues that would potentially distort the results to address[9]. We will use the Arellano-Bond method which will deal with these issues.

8. Loans from the BNDES expanded dramatically after the Global Financial Crisis, going from an average of R$46 billions before it to as high as R$190 billions in 2013. This strong policy action might have mitigated the effects of capital control measures on investment and thus we find that it is crucial to control for that.

9. There is a potential for endogenous regressors, there may be fixed effects that are correlated with the explanatory variables, and there could be autocorrelation due to the lagged variable.

3.4.2 Data

We obtained our Micro Data from the Worldscope Database on Datastream. We include all non-financial and non-public utility firms located in Brazil that reported data between 1994 and 2014. We augment this data with information of firm-level yearly loans from the BNDES[10] as well as firm-level export data from the MDIC (Ministry of Development, Industry and Foreign Trade).[11]

Worldscope only reports publicly available data, and so the sample has the potential to be biased towards larger firms. We start the sample with 651 firms from 1994 to 2014. Our first step is to drop all financial firms and public utility firms. This was done first by dropping firms with the relevant SIC codes but then double checked manually. Then, to minimize the possible effects of confounding factors, we restrict our attention to the four years before and after the controls: 2006 to 2013. After that, we dropped all firms that did not report data in both 2009 and 2010 to make sure that all firms in sample reported the effects of the controls. We also manually went through the remaining firms to remove any firms who had merged, or been acquired, as this produced unrepresentative spikes in data. We ended with 265 firms.

Table 3.6 shows some summary statistics for the firms in our sample, over the total period, as well as the four years before and after capital controls. As is evident the level of investment dropped noticeably, as did sales, while the intensive and extensive margin of BNDES loans jumped up significantly.

A description of the relevant variables taken from Worldscope (along with the descriptions from the Worldscope Datatype Definitions Guide) is listed in Table 3.7. We

10. BNDES provides data for all non automatic operations, which include all loans bigger than R$10 millions and account for more than half of total BNDES disbursements. As we are focusing on publicly trade companies, the smaller size loans should not be relevant for our analysis.

11. The MDIC only provides data that tells us whether a firm falls in one of the following 6 categories: (i) No exports; (ii) exports up to US$ 1 million; (iii) exports between US$ 1 and US$ 10 million; (iv) exports between US$ 10 and US$ 50 million; (v) exports between US$ 50 and US$ 100 million; and (vi) exports more than US$ 100 million. Thus, we can only split our sample in "big exporters" and "small exporters and non-exporting firms" without being able to control for firm size.

Variable	Total Sample	Pre-Controls	Post-Controls
Investment/Total Assets	0.0599	0.0709	0.0490
Tobin's Q	18.45	35.65	1.24
Sales/Total Assets	0.754	0.799	0.707
Number of BNDES Firms	29	28	31
Total BNDES Size of Loans	18,371	13,193	23,548

Table 3.6: Summary Statistics

define investment as capital expenditure, and normalize all variables by total assets.

3.4.3 Baseline Results

The results of our baseline regressions are shown on Table 3.8. The first column is the main regression. The second column includes business confidence at a yearly frequency, which should help act as a similar control - the coefficient here is positive, showing that an increase in business confidence led to higher levels of investment. The third is a novel control that we adapt from the Macrodata exercise. SynthInv is the first difference of synthetic Brazil's Investment (Investment appeared to have a trend, hence the first differencing). This variable should control for any shocks that would have affected countries similar to Brazil, and is unique to our approach to this problem. Again here, this control's coefficient is positive and significant, showing that a positive shock to investment in commodity producers (or countries similar to Brazil) increases investment within Brazil. Controlling for that we still see coefficients with the signs we would expect on After and After*BNDES. The coefficient on After is consistently negative and significant at the 1% percent level. The average size of the coefficient is right around 2 percentage points. Given that the average level of investment over assets is around 6.5%, this represents a significant decline in investment - about 30%. Additionally the coefficient on After*BNDES is consistently positive and significant at the 1-5% level. The size of the coefficient is around 1.2. This means that firms that had access to subsidized credit were able to invest more than those that did not have access, even conditioning on

Variable	Definition
Assets (total)	Sum of total current assets, long-term receivables, investment in unconsolidated subsidiaries, other investments, net property, plant, and equipment and other assets. Adjusted for inflation.
Capital Expenditure	Funds used to acquire fixed assets other than those associated with acquisitions. Includes, but not restricted to: Additions to property, plant and equipment; Investments in machinery and equipment.
Depreciation	Cost of a depreciable asset to the accounting periods covered during its expected useful life to a business. It is a non-cash charge for use and obsolescence of an asset.
Depletion	Cost allocation for natural resources such as oil and mineral deposits.
Amortization	Cost allocation for intangible assets such as patents and leasehold improvements, trademarks, bookplates, tools and film cost.
Net Sales	Net sales or revenues of the company.
Cash	Sum of cash and short term investments.
Cash Flow	Sum of net income and all non-cash charges or credits. It is the cash flow of the company.
Market Value	Market price-year end multiplied by common shares outstanding.

Table 3.7: Description of the Variables

the general negative trend in investment. Thus, we can infer that firms with BNDES access were cushioned against the constraints. Since the net effect of the two coefficients is still negative, it is reasonable to conclude that even those firms with the cushion may have had their investment levels drop as well. The coefficient on cash flow is also significantly positive, though perhaps not large in magnitude. Using other control variables, such as Tobin's Q or sales over total assets does not change the results significantly.

VARIABLES	(1) Investment	(2) Investment	(3) Investment
Inv_{t-1}	0.0760**	0.113***	0.0773***
	(0.0318)	(0.0319)	(0.0287)
After	-0.0139***	-0.0180***	-0.0202***
	(0.00356)	(0.00376)	(0.00410)
After*BNDES	0.0125**	0.0131**	0.0124***
	(0.00506)	(0.00550)	(0.00473)
Cashflow	0.000457***	0.000370*	0.000324*
	(0.000172)	(0.000203)	(0.000179)
busconf		0.000450**	
		(0.000188)	
synthinv			0.000271***
			(0.000102)
Constant	0.0529***	0.00423	0.0558***
	(0.00438)	(0.0189)	(0.00472)
Observations	1,384	1,384	1,384
Number of firms	243	243	243

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.8: Results - Baseline

3.4.4 Results by Size

To break down the sample by size, we take the average value of total assets over the period selected (2006 to 2013), and divide it into groups above the median and below the median. Summary statistics are shown on Table 3.9.

	Small	Large
Average Size	357,498	10,060,000
Average Investment/Assets	0.045	0.072

Table 3.9: Summary Statistics - Breakdown by Size

We then run the same regressions as above on the three different types of controls. The results can be seen on Table 3.10. Interestingly, we see that the effect after capital controls was almost twice a strong for large as for small firms. Additionally, the effect of the BNDES loans appear to have the same rough magnitude for both groups, but is far more significant for larger firms.[12] One potential explanation for this is that the dry up of foreign capital would have disproportionately affected larger firms, who had more access to international capital markets. Another is that small firms generally invest a smaller amount, in terms of a fraction of their total assets. Although we cannot speak to the first hypothesis, we can provide supporting evidence for the second. In general, large firms invested almost twice as much as a fraction of their total assets. Therefore the difference in the size of the coefficients makes more qualitative sense. In general, it appears that the fall in investment over assets from before capital controls to after was in the vicinity of 30-40% for both groups - in line with the aggregate numbers. This indicates, that unlike other control episodes (notably, that documented in Forbes (2007)), there was not a significantly different effect across differently sized firms.

3.4.5 Results by Exporter

We will now break down the results by the exporting status of individual firms. The export data was classified by overall size of exports, broken down into ranges. These were bucketed into 6 groups (from 0 to 5) manually, and then split into two groups to be as equally numbered as possible. Therefore, even though the column headings say 'Small Exporters' and 'Large Exporters' - these may not be strictly speaking, accurate. Really the distinction is between firms that export a lot, and firms that export less. Whether or not they are net exporters or that they export a considerable share of their production is not available to us. Summary statistics are shown on Table 3.11. Exporters

12. This result might be related to the fact that BNDES disbursements were tilted towards larger firms after the Global Financial Crisis (see De Mello and Garcia (2012), Lazzarini et al. (2014) and Bonomo, Brito, and Martins (2015) for further evidence).

VARIABLES	Small Investment	Large Investment	Small Investment	Large Investment	Small Investment	Large Investment
Inv_{t-1}	0.295	0.158**	0.244	0.118*	0.426	-0.00257
	(0.245)	(0.0655)	(0.188)	(0.0649)	(0.269)	(0.0729)
After	-0.008**	-0.0173***	-0.0122***	-0.0223***	-0.0115**	-0.0270***
	(0.00416)	(0.00602)	(0.00428)	(0.00692)	(0.00516)	(0.00696)
After*BNDES	0.0119	0.0176**	0.0129*	0.0183***	0.0107	0.0142**
	(0.00774)	(0.00757)	(0.00747)	(0.00707)	(0.00715)	(0.00611)
Cashflow	0.000263**	0.0973	0.000245	0.0842	0.000124	0.117
	(0.000129)	(0.1087)	(0.000203)	(0.0901)	(0.000135)	(0.106)
busconf			0.000656**	0.000347		
			(0.000308)	(0.000346)		
synthinv					0.000329**	0.000270**
					(0.000142)	(0.000117)
Constant	0.0282***	0.0487***	-0.0354	0.0202	0.0246*	0.0668***
	(0.0106)	(0.0109)	(0.0308)	(0.0307)	(0.0130)	(0.0130)
Observations	650	734	650	734	650	734
Number of firms	124	119	124	119	124	119

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.10: Results - Breakdown by Size

	Small Exporters	Large Exporters
Number	160	110
Average Size	2,346,970	9,396,383
Average Investment/Assets	0.0631	0.0536

Table 3.11: Summary Statistics - Breakdown by Size of Exports

that export a lot are, understandably, much larger than exporters that export less. However, interestingly, although they are larger, they appear to invest slightly less than smaller exporters. This is a different pattern that what emerged in the size breakdown.

We run again the baseline regressions for both groups. The results can be seen on Table 3.12. Firms that exported more were far less impacted by the capital controls - although investment declined, it declined by almost a full percentage point less than their importing counterparts. These results back the intuition that the capital controls were implemented for financial (exchange rate) reasons that would limit the harm to exporters caused by a rapidly appreciating exchange rate.

VARIABLES	Small Exporters Investment	Large Exporters Investment	Small Exporters Investment	Large Exporters Investment	Small Exporters Investment	Large Exporters Investment
Inv_{t-1}	0.0632*	0.763***	0.0943***	0.726***	0.0618*	0.824***
	(0.0374)	(0.161)	(0.0318)	(0.146)	(0.0345)	(0.187)
After	-0.0168***	0.00127	-0.0208***	-0.00654	-0.0229***	-0.00210
	(0.00588)	(0.00505)	(0.00590)	(0.00442)	(0.00659)	(0.00625)
After*BNDES	0.0214*	0.00450	0.0240*	0.00328	0.0216**	-0.000706
	(0.0113)	(0.00585)	(0.0135)	(0.00554)	(0.0109)	(0.00595)
Cashflow	0.000514***	0.0153	0.000328	0.0186	0.000402**	-0.0356
	(0.000174)	(0.0304)	(0.000235)	(0.0273)	(0.000177)	(0.0548)
busconf			0.000298	0.000872***		
			(0.000295)	(0.000282)		
synthinv					0.000258**	0.000367***
					(0.000124)	(0.000134)
Constant	0.0566***	0.00731**	0.0222	-0.0787**	0.0593***	0.00608
	(0.00617)	(0.00943)	(0.0293)	(0.0318)	(0.00693)	(0.0121)
Observations	775	609	775	609	775	609
Number of firms	160	112	160	112	160	112

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.12: Results - Breakdown by Size of Exports

Thus we have shown, both in aggregate and broken down by size and export status, that investment over total assets dropped after the imposition of capital controls. Pretty consistently, the magnitude of the drop was about 30 to 40% of its original value. Large exporters, and firms that had access to the BNDES for loans did not suffer as large of a drop off.

3.5 Conclusion

In this work, we have shown that investment in Brazil unambiguously declined after the imposition of capital controls in late 2009. Unconditionally, we showed with micro data investment over total assets dropped at the firm level between 30 and 40 percent. Firms of different sizes were not generally differentially affected, but larger exporters fared better than smaller exporters. Additionally, firms that had access to subsidized credit from Brazil's Development Bank (BNDES) also performed much better than those that did not. Conditionally, we showed with macro data that Brazil's total investment was close to 20 percent lower in 2013 *than it would have been* had controls not been put in place. Moreover, although larger exporters seem to have suffered less from the controls, we do not find any significant effect on real exports after their imposition.

The support for macroprudential policies in general and particularly for prudential capital controls has increased substantially after the Global Financial Crisis. In theory, capital controls can be desirable and welfare improving if they help to avoid financial and macroeconomic instability. However, if they have a disproportionate effect on investment as our results indicate, they might also have strong and long-lasting effects on potential growth, especially in economies with low savings rate such as Brazil. These effects should be taken into account to evaluate the welfare impacts of such measures.

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Appendix A

Appendix for Chapter 1

A.1 Data

The dataset includes quarterly data for Argentina, Brazil, Chile, Colombia, Peru and South Africa for Emerging Economies and Australia, Canada, New Zealand and Norway for Advanced Economies. The sample periods vary across countries.They are: Argentina, Australia, Canada, New Zealand and Norway 1994Q1-2013Q4, Brazil 1994Q2-2013Q4, South Africa 1995Q1-2013Q4, Colombia and Peru 1997Q1-2013Q4 and Chile 1999Q2-2011Q3.

Real Output and Real Investment: all the data are from national sources, deflated by each own deflator and seasonally adjusted using ARIMA X-12.

Trade Balance to GDP ratio: all the data are from national sources, dividing nominal trade balance by nominal GDP.

Real Credit: obtained by dividing nominal credit to non-financial sector by the CPI and seasonally adjusted using ARIMA X-12. For Argentina, Australia, Brazil, Canada, Norway and South Africa, nominal credit to non-financial sector is obtained from the BIS in `http://www.bis.org/statistics/totcredit.htm`. For Chile, Colombia, Peru and New Zealand, nominal credit to non-financial sector is obtained from each country's Central Bank. CPI is obtained from national statistical agencies.

Real Interest Rate: for emerging economies, the country specific interest rate in the international financial markets, R, is measured as the sum of J. P. Morgan's EMBI+ sovereign spread and the U.S. real interest rate. The U.S. real interest rate is measured by the interest rate on the three-month U.S. Treasury bill minus a measure of the U.S. expected inflation. EMBI+ is a composite index of different U.S. dollar-denominated bonds on four markets: Brady bonds, Eurobonds, U.S. dollar local markets and loans. The spreads are computed as an arithmetic, market-capitalization-weighted average of bond spreads over the U.S. Treasury bonds of comparable duration. For advanced economies, the country interest rate is measured by the interest rate on the three-month bill (Central Bank policy rate when this is not available) minus expected inflation (12-month accumulated inflation when this is not available).

Real Exchange Rates: obtained from the BIS effective exchange rate indices database, particularly the quarterly average of the broad indices. Nominal EERs are calculated as geometric weighted averages of bilateral exchange rates. Real EERs are the same weighted averages of bilateral exchange rates adjusted by relative consumer prices. The weighting pattern is time-varying, and the most recent weights are based on trade in the 2008-10 period (see broad and narrow weights in http://www.bis.org/statistics/eer.htm). An increase in the index indicates an appreciation.

Real Commodity Export Price: calculated following Deaton and Miller (1996) and Chen and Rogoff (2003) through 5 steps: (i) I find the equivalence between SITC level 4 groups and the IMF commodities database (composed by 51 commodities); (ii) I calculate for each country the value of each primary commodity exports using the UN COMTRADE database, which provides annual trade data for SITC level 4 groups, and take the average; (iii) I calculate the weights for each commodity by dividing its average value of exports for each commodity by the average total value of primary commodity exports; (iv) I use the weights to compute a geometric weighted-average of (US-dollar based) monthly nominal commodity export prices; and (v) I calculate the real commodity price index by dividing the nominal price index by the U.S. import price of manufactured articles from industrialized countries.

Figure A.1 shows the average time series of all detrended variables for each group of countries and the IMF real commodity price.

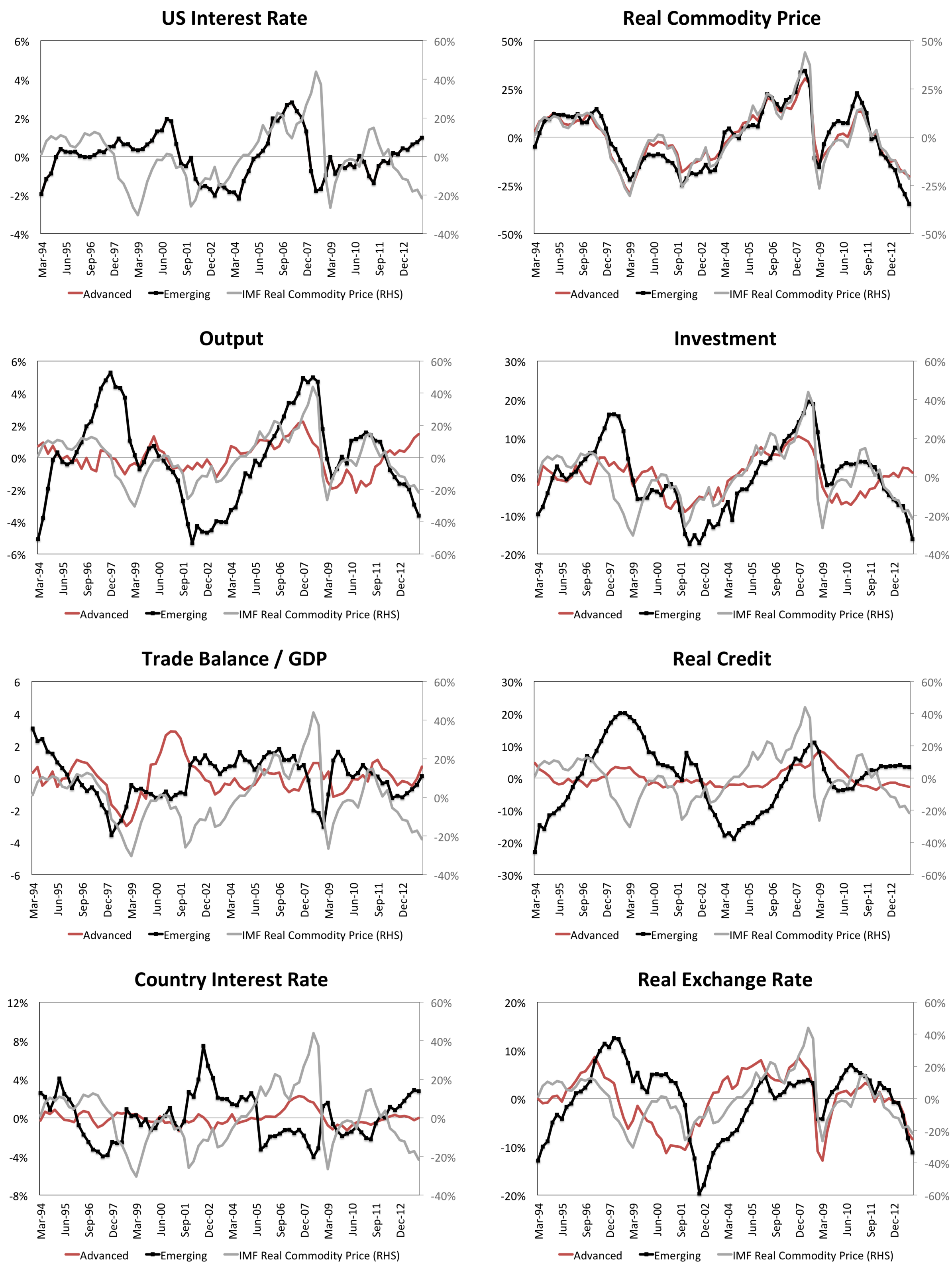

Figure A.1: Business Cycles and Commodity Prices.

Note: The data are the simple average of the indicators for the Emerging (Argentina, Brazil, Chile, Colombia, Peru and South Africa) and Advanced (Australia, Canada, New Zealand and Norway) main commodity exporters. The data are sampled quarterly from 1994:Q1-2013:Q4.

A.2 Equilibrium Conditions

- Lagrange multiplier

$$\lambda_t = U_t' A_1(c_t^T, c_t^N) - b\beta U_{t+1}' A_1(c_{t+1}^T, c_{t+1}^N) \tag{A.1}$$

where

$$U_t' = \left(c_t - \frac{h_{CM,t}^{\omega^{CM}}}{\omega^{CM}} - \frac{h_{T,t}^{\omega^T}}{\omega^T} - \frac{h_{N,t}^{\omega^N}}{\omega^N} \right)^{-\sigma} \tag{A.2}$$

- Labor supply

$$E_t[\lambda_{t+1} w_{CM,t+1}] = E_t[U_{t+1}' h_{CM,t+1}^{\omega^{CM}-1}] \tag{A.3}$$

$$E_t[\lambda_{t+1} w_{T,t+1}] = E_t[U_{t+1}' h_{T,t+1}^{\omega^T-1}] \tag{A.4}$$

$$E_t[\lambda_{t+1} w_{N,t+1}] = E_t[U_{t+1}' h_{N,t+1}^{\omega^N-1}] \tag{A.5}$$

- Price of nontradables

$$p_t^N = \frac{U_t' A_2(c_t^T, c_t^N) - b\beta U_{t+1}' A_2(c_{t+1}^T, c_{t+1}^N)}{U_t' A_1(c_t^T, c_t^N) - b\beta U_{t+1}' A_1(c_{t+1}^T, c_{t+1}^N)} \tag{A.6}$$

- Euler equation for household debt

$$\lambda_t = \beta R_t^* E_t \lambda_{t+1} \tag{A.7}$$

- Capital accumulation and investment demand

$$k_{j,t+1} = (1-\delta)k_{j,t} + i_{j,t} \left(1 - \frac{\phi^j}{2} \left(\frac{i_{j,t}}{i_{j,t-1}} - 1 \right)^2 \right) \tag{A.8}$$

$$\lambda_t q_{j,t} = \beta E_t \left\{ \lambda_{t+1} \left[q_{j,t+1}(1-\delta) + \alpha^j \frac{p_{t+1}^j y_{t+1}^j}{k_{j,t+1}} \right] \right\} \tag{A.9}$$

$$E_t\left\{\lambda_{t+1}q_{j,t+1}\left[1-\frac{\phi^j}{2}\left(\frac{i_{j,t+1}}{i_{j,t}}-1\right)^2-\phi^j\left(\frac{i_{j,t+1}}{i_{j,t}}\right)\left(\frac{i_{j,t+1}}{i_{j,t}}-1\right)\right]\right\}+$$

$$\beta E_t\left\{\lambda_{t+2}q_{j,t+2}\phi^j\left(\frac{i_{j,t+2}}{i_{j,t+1}}\right)^2\left(\frac{i_{j,t+2}}{i_{j,t+1}}-1\right)\right\}=E_t[\lambda_{t+1}(1+\eta^j\xi^j_{t+1})] \quad \text{(A.10)}$$

for $j = CM, T, N$

- Production function

$$y_t^{CM} = a_{CM,t}k_{CM,t}^{\alpha^{CM}}h_{CM,t}^{1-\alpha^{CM}} \quad \text{(A.11)}$$

$$y_t^T = a_{T,t}k_{T,t}^{\alpha^T}cm_{T,t}^{\gamma^T}h_{T,t}^{1-\alpha^T-\gamma^T} \quad \text{(A.12)}$$

$$y_t^N = a_{N,t}k_{N,t}^{\alpha^N}h_{N,t}^{1-\alpha^N} \quad \text{(A.13)}$$

- Commodities domestic demand

$$\left(1+\eta^T\frac{R_t-1}{R_t}\right)p_t^{CM} = \gamma^T\frac{y_t^T}{cm_{T,t}} \quad \text{(A.14)}$$

- Labor demand

$$\left(1+\eta^{CM}\frac{R_t-1}{R_t}\right)w_{CM,t} = (1-\alpha^{CM})\frac{p_t^{CM}y_t^{CM}}{h_{CM,t}} \quad \text{(A.15)}$$

$$\left(1+\eta^T\frac{R_t-1}{R_t}\right)w_{T,t} = (1-\alpha^T-\gamma^T)\frac{y_t^T}{h_{T,t}} \quad \text{(A.16)}$$

$$\left(1+\eta^N\frac{R_t-1}{R_t}\right)w_{N,t} = (1-\alpha^N)\frac{p_t^N y_t^N}{h_{N,t}} \quad \text{(A.17)}$$

- Working capital

$$p_t^N(d_t^{CM}-R_{t-1}d_{t-1}^{CM}) = \eta^{CM}\left(\frac{i_{CM,t}+w_{CM,t}h_{CM,t}}{R_t}-(i_{CM,t-1}+w_{CM,t-1}h_{CM,t-1})\right) \quad \text{(A.18)}$$

$$p_t^N(d_t^T-R_{t-1}d_{t-1}^T) = \eta^T\left(\frac{p_t^{CM}cm_{T,t}+i_{T,t}+w_{T,t}h_{T,t}}{R_t}-(p_{t-1}^{CM}cm_{T,t-1}+i_{T,t-1}+w_{T,t-1}h_{T,t-1})\right) \quad \text{(A.19)}$$

$$p_t^N(d_t^N - R_{t-1}d_{t-1}^N) = \eta^N\left(\frac{i_{N,t} + w_{N,t}h_{N,t}}{R_t} - (i_{N,t-1} + w_{N,t-1}h_{N,t-1})\right) \tag{A.20}$$

- Tradables market clearing

$$y_t^T = c_t^T + i_t + tb_t^T \tag{A.21}$$

- Commodities trade balance

$$tb_t^{CM} = p_t^{CM}(y_t^{CM} - cm_{T,t}) \tag{A.22}$$

- Trade balance

$$tb_t = tb_t^T + tb_t^{CM} \tag{A.23}$$

- Country interest rate

$$r_t^* = \bar{r^*} + \psi^D(e^{d_t^* - \bar{d^*}} - 1) + \psi^{CM}(e^{p_t^{CM} - \bar{p}^{CM}} - 1) + \epsilon_t^{r^*} \tag{A.24}$$

- Total net foreign assets

$$d_t^* = d_t^{*H} + d_t^{*B} \tag{A.25}$$

- Current account

$$ca_t = tb_t - r_t^* d_t^* \tag{A.26}$$

- Net foreign assets evolution

$$ca_t = d_{t+1}^* - d_t^* \tag{A.27}$$

- Banking sector balance sheet

$$n_t + d_t^{*B} = p_t^N d_t \tag{A.28}$$

- Total debt

$$d_t = d_t^{CM} + d_t^T + d_t^N \tag{A.29}$$

- Net worth evolution

$$n_t = \theta^B \left\{ \left(R_t \frac{p_t^N}{p_{t-1}^N} - R_{t-1}^* \right) p_{t-1}^N d_{t-1} + R_{t-1}^* n_{t-1} \right\} + \nu^B p_t^N d_{t-1} \tag{A.30}$$

- Leverage constraint

$$p_t^N d_t = \phi^B n_t \tag{A.31}$$

- Market clearing nontradables

$$y_t^N = c_t^N \tag{A.32}$$

- Market clearing labor

$$h_t = h_{CM,t} + h_{T,t} + h_{N,t} \tag{A.33}$$

- Total investment

$$i_t = i_{CM,t} + i_{T,t} + i_{N,t} \tag{A.34}$$

- Total output

$$y_t = tb_t^{CM} + y_t^T + p_t^N y_t^N \tag{A.35}$$

- Exogenous shocks

$$log(p_{t+1}^{CM}) - log(\bar{p}^{CM}) = \rho_1^{PCM} log(p_t^{CM} - log(\bar{p}^{CM})) + \rho_2^{PCM} log(p_{t-1}^{CM} - log(\bar{p}^{CM})) + \epsilon_t^{PCM} \tag{A.36}$$

$$log(a_{CM,t+1}) = \rho^{CM} log(a_{CM,t}) + \epsilon_t^{CM} \tag{A.37}$$

$$log(a_{T,t+1}) = \rho^T log(a_{T,t}) + \epsilon_t^T \tag{A.38}$$

$$log(a_{N,t+1}) = \rho^N log(a_{N,t}) + \epsilon_t^N \tag{A.39}$$

A.3 STEADY STATE CALCULATION

First, normalize r^* to the calibrated value. Using the foreign sector equation and household euler equation we can get

$$d^* = \bar{d}^* \tag{A.40}$$

$$ca = 0 \tag{A.41}$$

$$tb = r^* d^* \tag{A.42}$$

$$\beta = \frac{1}{R^*} \tag{A.43}$$

From the net worth evolution equation we then get

$$R = \frac{1 - \theta^B R^* - \nu^B \phi^B}{\phi^B \theta^B} + R^* \tag{A.44}$$

From the investment demand equations we obtain

$$q_{CM} = \left(1 + \eta^{CM} \frac{R_t - 1}{R_t}\right) \tag{A.45}$$

$$q_T = \left(1 + \eta^T \frac{R_t - 1}{R_t}\right) \tag{A.46}$$

$$q_N = \left(1 + \eta^N \frac{R_t - 1}{R_t}\right) \tag{A.47}$$

and the auxiliary variables representing the shadow rent of capital

$$u_{CM} \equiv \alpha^{CM} \frac{p^{CM} y^{CM}}{k_{CM}} = q_{CM}(R^* - 1 + \delta) \tag{A.48}$$

$$u_T \equiv \alpha^T \frac{y^T}{k_T} = q_T(R^* - 1 + \delta) \tag{A.49}$$

$$u_N \equiv \alpha^N \frac{p^N y^N}{k_N} = q_N(R^* - 1 + \delta) \tag{A.50}$$

Using the output equation and the definition of the shadow rental rate of capital we get the capital to hours ratio for the commodity sector

$$\frac{k_{CM}}{h_{CM}} = \left(\frac{\left(1 + \eta^{CM} \frac{R_t - 1}{R_t}\right) u_{CM}}{\alpha^{CM} p^{CM} a_{CM}} \right)^{\frac{1}{\alpha^{CM} - 1}} \tag{A.51}$$

From the labor demand by firms in the commodity sector we then get

$$w_{CM} = \frac{(1 - \alpha^{CM}) p^{CM} a_{CM}}{\left(1 + \eta^{CM} \frac{R_t - 1}{R_t}\right)} \left(\frac{k_{CM}}{h_{CM}} \right)^{\alpha^{CM}} \tag{A.52}$$

Using the definition of the shadow rental rate of capital and the demand for commodities in the final tradable goods sector, its output can be rewritten as

$$y^T = \theta^T a_T k_T^{\alpha^T + \gamma^T} h_T^{1 - \alpha^T - \gamma^T} \tag{A.53}$$

where $\theta^T = \left(\frac{\gamma^T u_T}{\alpha_T p^{CM}} \right)^{\gamma^T}$

Using the previous equation and the definition of the shadow rental rate of capital we get the capital to hours ratio for the final tradable goods sector

$$\frac{k_T}{h_T} = \left(\frac{\left(1 + \eta^T \frac{R - 1}{R}\right) u_T}{\alpha^T \theta^T a_T} \right)^{\frac{1}{\alpha^T + \gamma^T - 1}} \tag{A.54}$$

From the labor demand by firms in the final tradable goods sector sector

$$w_T = \frac{(1 - \alpha^T - \gamma^T) \theta^T a_T}{\left(1 + \eta^T \frac{R - 1}{R}\right)} \left(\frac{k_T}{h_T} \right)^{\alpha^T + \gamma^T} \tag{A.55}$$

Then we have to solve numerically the following system of equations to obtain p^N,

$\left(\frac{k_N}{h_N}\right)$, h_N and $reer$

$$u_N = p^N \alpha^N a_N \left(\frac{k_N}{h_N}\right)^{\alpha^N - 1} \tag{A.56}$$

$$\left(1 + \eta^N \frac{R-1}{R}\right)\left(\frac{reer}{1-\beta b} h_N^{\omega^N - 1}\right) = p^N (1-\alpha^N) a_N \left(\frac{k_N}{h_N}\right)^{\alpha^N} \tag{A.57}$$

$$reer = (\chi^\mu + (1-\chi)^\mu ((p^N)^{1-\mu}))^{1/(1-\mu)} \tag{A.58}$$

$$p^N = \left(\frac{1-\chi}{\chi}\right)\left(\frac{a_T \theta^T \left(\frac{k_T}{h_T}\right)^{\alpha^T + \gamma^T} \left(\frac{w_T(1-\beta b)}{reer}\right)^{\omega^T - 1} - i_T - i_{CM} - \delta\left(\frac{k_N}{h_N}\right) h_N - tb + tb^{CM}}{a_N \left(\frac{k_N}{h_N}\right)^{\alpha^N} h_N}\right)^{\frac{1}{\mu}} \tag{A.59}$$

where $i_T = \delta\left(\frac{k_T}{h_T}\right)\left(\frac{w_T(1-\beta b)}{reer}\right)^{\omega^T - 1}$, $i_{CM} = -\delta\left(\frac{k_{CM}}{h_{CM}}\right)\left(\frac{w_{CM}(1-\beta b)}{reer}\right)^{\omega^{CM} - 1}$,

$$tb^{CM} = p^{CM}\left(a_{CM}\left(\frac{k_{CM}}{h_{CM}}\right)^{\alpha^{CM}}\left(\frac{w_{CM}(1-\beta b)}{reer}\right)^{\omega^{CM}-1} - \left(\frac{\gamma^T u_T}{\alpha^T p^{CM}\left(1+\eta^T \frac{R_t - 1}{R_t}\right)}\right)\left(\frac{k_T}{h_T}\right)\left(\frac{w_T(1-\beta b)}{reer}\right)^{\omega^T - 1}\right)$$

Using the labor supply equilibrium conditions

$$h_{CM} = \left(\frac{(1-\beta b) w_{CM}}{rer}\right)^{\frac{1}{\omega^{CM}-1}} \tag{A.60}$$

$$h_T = \left(\frac{(1-\beta b) w_T}{rer}\right)^{\frac{1}{\omega^T - 1}} \tag{A.61}$$

$$w_N = \frac{rer}{1-\beta b} h_N^{\omega^N - 1} \tag{A.62}$$

Using the previous equations

$$k_{CM} = \left(\frac{k_{CM}}{h_{CM}}\right) h_{CM} \tag{A.63}$$

$$k_T = \left(\frac{k_T}{h_T}\right) h_T \tag{A.64}$$

$$k_N = \left(\frac{k_N}{h_N}\right) h_N \tag{A.65}$$

Combining the definition of the shadow rental rate of capital and the demand for commodities in the tradable final goods sector

$$cm_T = \left(\frac{\gamma^T u_T}{\alpha^T p^{CM} \left(1 + \eta^T \frac{R_t - 1}{R_t}\right)} \right) k_T \tag{A.66}$$

$$tb^{CM} = p^{CM}(y^{CM} - cm_T) \tag{A.67}$$

From the trade balance equation

$$tb^T = tb - tb^{CM} \tag{A.68}$$

From the capital accumulation equations we get

$$i_{CM} = \delta k_{CM} \tag{A.69}$$

$$i_T = \delta k_T \tag{A.70}$$

$$i_N = \delta k_N \tag{A.71}$$

Sectoral outputs are given by

$$y^{CM} = a_{CM} k_{CM}^{\alpha^{CM}} h_{CM}^{1-\alpha^{CM}} \tag{A.72}$$

$$y^T = a_T k_T^{\alpha^T} cm_T^{\gamma^T} h_T^{1-\alpha^T-\gamma^T} \tag{A.73}$$

$$y^N = a_N k_N^{\alpha^N} h_N^{1-\alpha^N} \tag{A.74}$$

Using the equilibrium equation for the price of nontradables

$$c^T = \left(\frac{\chi}{1-\chi} p^N \right)^{\mu} y^N \tag{A.75}$$

Nontradable market clearing yields

$$c^N = y^N \tag{A.76}$$

Using the working capital constraints we can get firms' borrowing from the banking sector

$$d^{CM} = \eta^{CM} \left(\frac{i_{CM} + w_{CM} h_{CM}}{p^N R} \right) \tag{A.77}$$

$$d^T = \eta^T \left(\frac{p^{CM} cm_T + i_T + w_T h_T}{p^N R} \right) \tag{A.78}$$

$$d^N = \eta^N \left(\frac{i_N + w_N h_N}{p^N R} \right) \tag{A.79}$$

$$d = d^{CM} + d^T + d^N \tag{A.80}$$

Banks' foreign borrowing and net worth are then given by

$$d^{*B} = \frac{(\phi^B - 1)}{\phi^B} p^N d \tag{A.81}$$

$$n = p^N d - d^{*B} \tag{A.82}$$

Using the equation for total foreign borrowing

$$d^{*H} = d^* - d^{*B} \tag{A.83}$$

Aggregate hours, investment and GDP are given by

$$h = h_{CM} + h_T + h_N \tag{A.84}$$

$$i = i_{CM} + i_T + i_N \tag{A.85}$$

$$y = tb^{CM} + y^T + p^N y^N \tag{A.86}$$

Using the definition of the consumption basket

$$c = [\chi(c^T)^{1-1/\mu} + (1-\chi)(c^N)^{1-1/\mu}]^{\frac{1}{1-1/\mu}} \tag{A.87}$$

Using the optimality conditions from the households problem we then get

$$U' = \left(c - \frac{h_{CM}^{\omega^{CM}}}{\omega^{CM}} - \frac{h_T^{\omega^T}}{\omega^T} - \frac{h_N^{\omega^N}}{\omega^N}\right)^{-\sigma} \tag{A.88}$$

$$A_1(c^T, c^N) = \chi\left(\frac{c}{c^T}\right)^{\frac{1}{\mu}} \tag{A.89}$$

$$A_2(c^T, c^N) = (1-\chi)\left(\frac{c}{c^N}\right)^{\frac{1}{\mu}} \tag{A.90}$$

$$\lambda_t = (1-b\beta)U' A_1(c^T, c^N) \tag{A.91}$$

Appendix B

Appendix for Chapter 2

B.1 A Brief History of Reserve Accumulation

International reserves are defined as all liquid assets in foreign currency that are in the balance sheet of the government. Under the Bretton Woods system (1944-73), the US dollar functioned as the world's reserve currency, so dollar denominated risk free assets became the main component of international reserves along with gold. After its end, many countries adopted flexible exchange rate regimes, in which case in theory international reserves should not be necessary. However, the tendency of liberalization in the capital account lead to a focus in the role of reserves to mitigate the effects of highly volatile financial flows.

Figure B.1 shows the evolution of international reserves to GDP ratio for developed and emerging economies since 1970. Beginning in the end of the 80s, we can see a strong divergence between the path of reserves for these 2 groups. While advanced economics started to reduce reserve holdings, emerging economies more than doubled theirs as a percent of GDP, with the pace of accumulation increasing a lot after the Russian and Asian crisis of the late 90s. This phenomenon seems to be related to the underdevelopment of domestic financial systems in emerging markets and the desire of these countries to self-insure against a sharp deterioration in external financing conditions after the strong impacts of the crisis of the late 90s.

In an attempt to evaluate how much international reserves a sovereign should hold in an environment of highly volatile capital flows, Pablo Guidotti, Argentinean deputy finance minister, and Alan Greenspan, chairman of the Federal Reserve, created at the end of the nineties the so-called Guidotti-Greenspan rule. This rule stated that the optimal level of reserves should be full coverage of foreign liabilities coming due within a year and became the most widely used rule of thumb for determining the adequate level of international reserves even today. After that, several authors offered different explanations for the strong buildup of international reserves by emerging markets but,

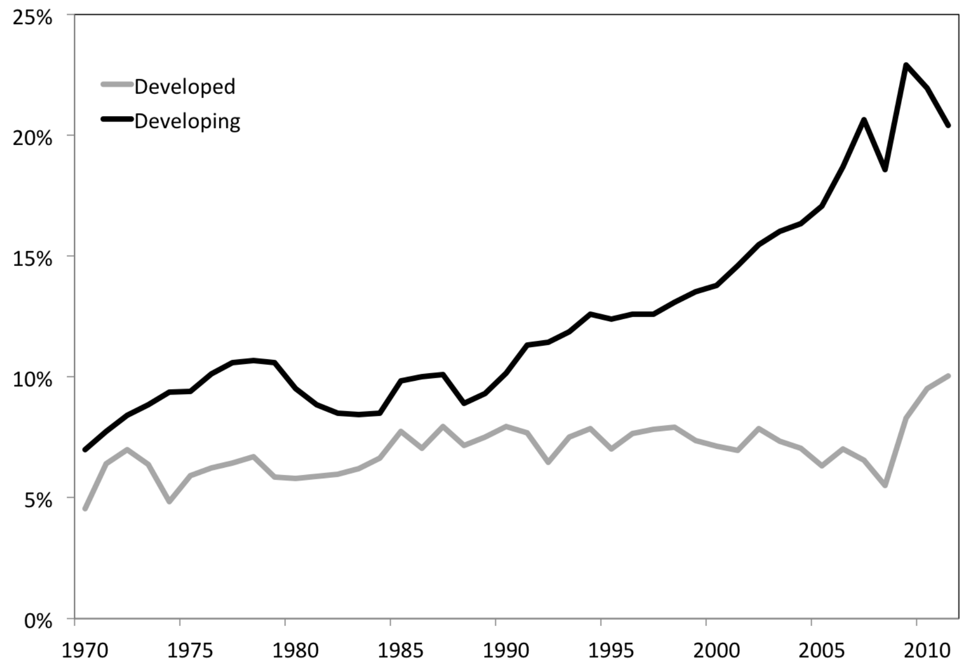

Figure B.1: International Reserves (% of GDP)

Note: The data are the simple average sampled annually from 1970:2011. All variables are expressed in percentage points of GDP.
Source: Authors' computations based on World Bank World Development Indicators (WDI) database.

as noted by De Gregorio (2011), "an explanation and robust conclusions on the optimal level of reserves are still lacking.". This paper contributes to fill this gap with a still unexplored explanation, the role of reserves as collateral for external borrowing in periods of financial turmoil.